

RECEIVED
JAN 10 1964
U.S. AIR FORCE
HEADQUARTERS
AIR FORCE
WASHINGTON, D.C.

6



RECEIVED
JAN 10 1964
U.S. AIR FORCE
HEADQUARTERS
AIR FORCE
WASHINGTON, D.C.

INTERNATIONAL

RECEIVED
JAN 10 1964
U.S. AIR FORCE
HEADQUARTERS
AIR FORCE
WASHINGTON, D.C.

RECEIVED
JAN 10 1964
U.S. AIR FORCE
HEADQUARTERS
AIR FORCE
WASHINGTON, D.C.

58.5

CUC - H04246-6-P 775
9848

BULLETIN

OF THE

658-5405
B 874a



Operations Research Society of America

Supplement 1

OPERATIONS RESEARCH

Volume 17, 1969

Program of the Joint ORSA-AAS Meeting

REGISTRATION INFORMATION	B-3
COMMITTEE FOR THE MEETING	B-8
INDEX OF PARTICIPANTS	B-9
SCHEDULE OF EVENTS	B-17
PROGRAM OF THE MEETING	B-21
ABSTRACTS OF THE PAPERS	B-72

Society Affairs

The ORSA Council Meeting	B-165
The Future of the Bulletin	B-168
Treasurer's Report	B-169

News and Announcements	B-173
------------------------------	-------

Planning Challenges of the 70's in Space and the Public Domain



JOINT NATIONAL MEETING 35th NATIONAL ORSA 15th ANNUAL AAS

P 9545

PRECIS: *Exploration of space as a beginning, now exploitation to benefit society here on Earth must begin. Likewise, continued development of sophisticated methodology in OR must be paralleled by applications to man's social, economic and physical environment. This meeting is designed to accept such challenges. The possible space mission of the 70s will be reviewed for exploitation potential in the astronautical theme session A. Public domain problems and potential application of OR will be examined in theme session B. Continued development of the astronautical sciences and OR techniques will be featured in the remaining specialist sessions. The interdisciplinary stimulation in this meeting should contribute to the global understanding necessary to improving man's total environment.*

GEORGE W. MORGENTHAU
General Program Chairman

PARTICIPATING SOCIETIES

JUNE 17-20, 1969
BROWN PALACE—
COSMOPOLITAN HOTELS
DENVER, COLORADO

Rocky Mountain Section AIAA
American Institute of Biological Sciences
The Institute of Management Sciences
Working Group on Extraterrestrial Resources
Society of Logistics
The American Water Resources Association

REGISTRATION AND GENERAL INFORMATION

Registration

The registration desk will be located in the Main Lobby of the Brown Palace Hotel. Attendees who arrive in Denver on Monday, June 16, are urged to register sometime between 6:00 P.M. and 10:00 P.M. The registration desk will be open:

Monday, June 16	6:00 PM to 10:00 PM
Tuesday, June 17	8:00 AM to 5:00 PM
Wednesday, June 18	8:00 AM to 5:00 PM
Thursday, June 19	8:00 AM to 5:00 PM
Friday, June 20	8:00 AM to 3:00 PM

Registration fees will be as follows:

ORSA Member	\$15.00
AAS Member	15.00
Members Participating Societies	15.00
Non-Members	20.00
Full-Time Students	3.00

Attendees are expected to register and pay the established fees.

Advanced registration is urged in order to assist the Committee in providing adequate facilities. The enclosed card should be used for this purpose.

Tickets for the luncheons and banquets must be purchased by 5:00 P.M. the day before the event, in order to meet hotel guarantee requirements. Attendees are urged to purchase tickets at the time of registration or preregistration.

There will be a cash bar open Monday evening from 6:00 P.M. to 10:00 P.M. for the convenience of registrants. Cocktails will be served at 6:30 P.M. on a cash basis, before the AAS Banquet on Tuesday evening, and before the ORSA Banquet on Wednesday evening.

Accommodations

The Brown Palace Hotel has blocked off 400 rooms, and the Cosmopolitan Hotel has blocked off 250 rooms for this meeting. These rooms will not be held, however, after May 26, unless they have been individually reserved by attendees, who should make these reservations directly with the hotel of their choice using the enclosed card. The daily rates are as follows:

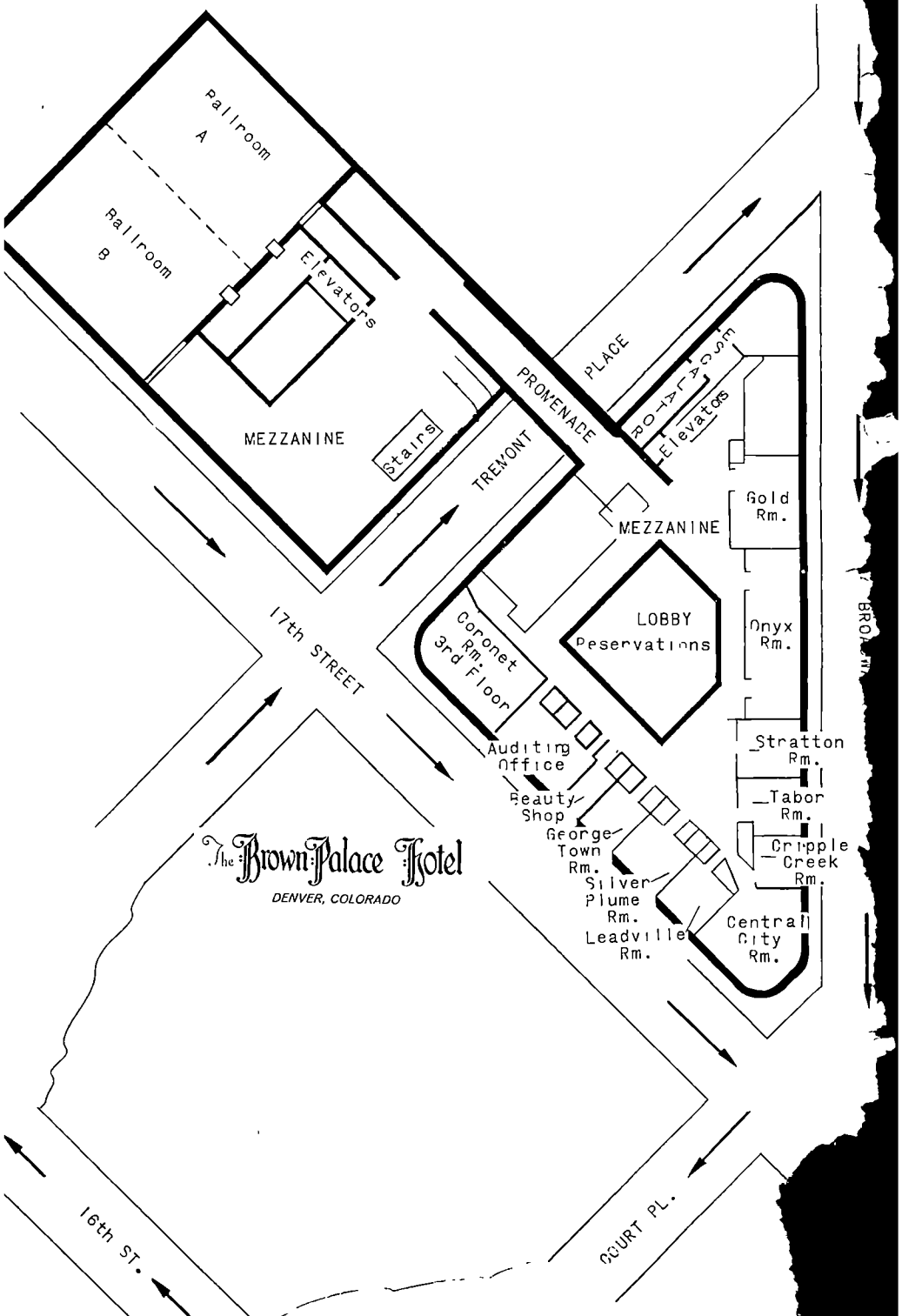
	<i>Single</i>	<i>Double</i>	<i>Twin</i>	<i>Suites</i>
Brown Palace Hotel	\$14-20	\$19-22	\$19-26	\$35-85
Cosmopolitan Hotel	\$14-22	\$19-27	\$20-27	\$35-70

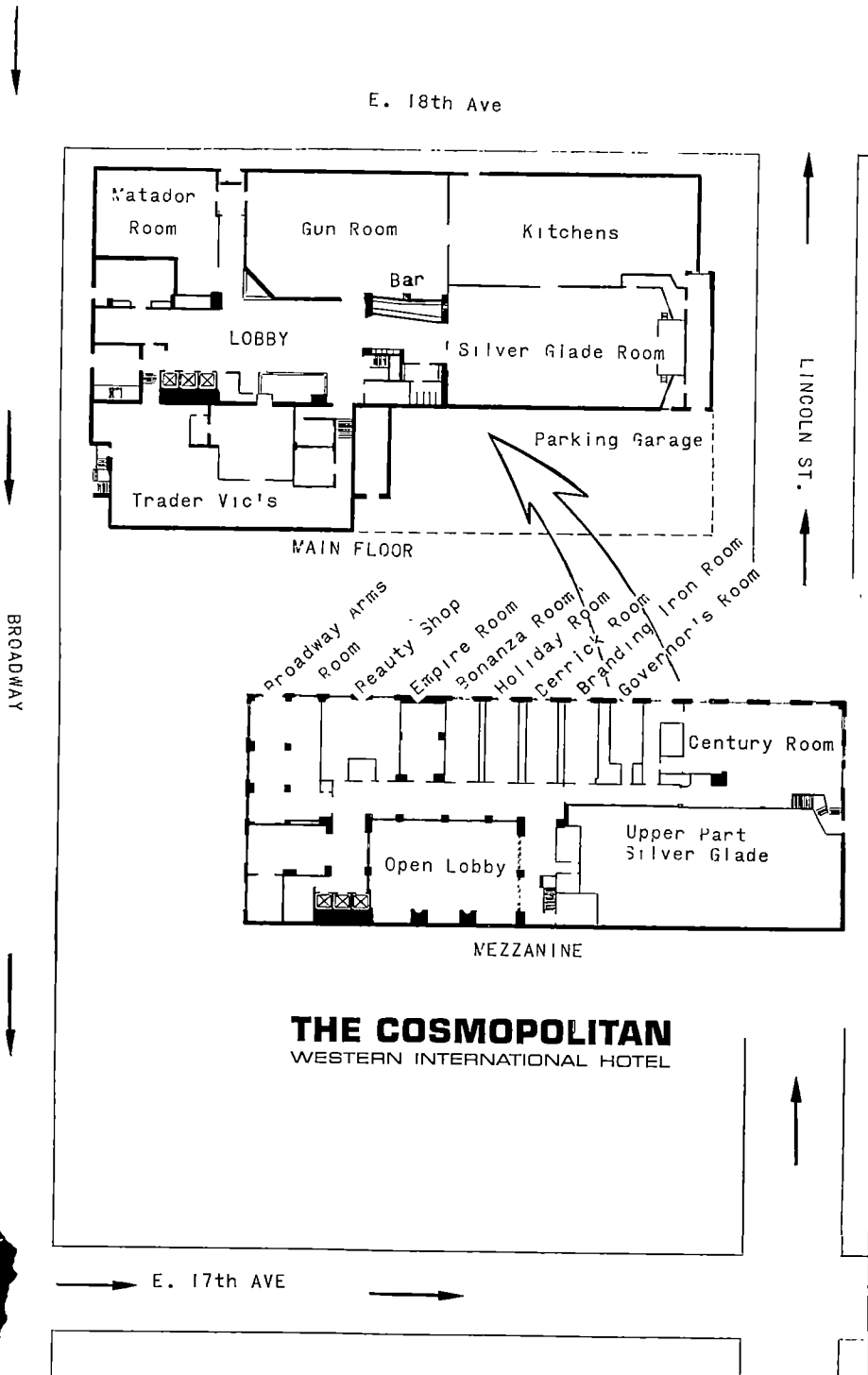
Travel

Denver is served by the following airlines through Stapleton International Airport:

United	East-West	Braniff	Southeast, Texas
TWA	East-West	Western	Southwest, West
Americ	East-West	Continental	East-West, Southwest
		Frontier	Rocky Mountain Region

Limousine service is available direct to the Brown Palace and Cosmopolitan Hotels. Running time is approximately 20 minutes. Taxi service is also available at the Airport. Those not needed to participate in the activities of this meeting. The meeting hotels are on the street from each other in downtown Denver, and are within walking distance of restaurants, movies, Denver Public Library, State and City government buildings, department stores and the financial district. Rental cars and parking facilities are available at the hotels.





Meeting Information

Denver is served by the following railroads using the Union Station, located 10 minutes by taxi from the meeting hotels:

Union Pacific
Denver and Rio Grande

Missouri Pacific
Burlington

TRAVEL RESERVATION BOOTH (BROWN PALACE)

Continental Airlines will provide travel arrangement service regardless of mode of transportation or airline, for anyone needing this assistance. United Airlines also has a ticket counter in this hotel.

COPIES OF PAPERS

Preprints of theme session papers (A and B) and some specialist session papers (non A, B sessions) will be on sale at the meeting beginning Monday evening. Theme session papers will be published by the American Astronautical Society in the Advances in the Astronautical Sciences series, and the Science and Technology series. Consideration will be given to the publication of the specialist session papers, if paper availability and interest warrant it. Orders for these publications will be accepted during the meeting at the registration desk.

LENGTH OF PAPERS

Invited papers are scheduled for 15 minutes, with an additional 5 minutes for discussion. Contributed papers are scheduled for 10 minutes, with an additional 5 minutes for discussion. Session Chairmen may modify these practices. The program is tightly scheduled, and all authors must stay within the time allowed by the Chairman.

DESIGNATION OF PAPERS

A uniform numbering system of all papers has been established to enable quick and easy cataloging and identification. Preprints will have these numbers just as they are in this Bulletin.

BOOK EXHIBIT

Major suppliers of technical books, representing all of the major publishers, will have exhibits of books of interest to AAS, ORSA, and other participating Society members.

TECHNOLOGY EXHIBITS

Selected educational institutions, governmental agencies, and industrial firms have been invited to provide exhibits related to the theme of the meeting.

THE FIRST NATIONAL SPACE ART SHOW

The First National Space Art Show will be held in the Central City Room of the Brown Palace, June 17 thru June 20, in conjunction with the meeting. The show will have both an invitational and a juried section, and artists who enter are requested to express their interpretations of the space frontier through all media. Subjects will be space-related according to the creative inspiration of the individual artist. Awards will be presented in each of five categories: 1) Oils and Acrylics, 2) Watercolor, Graphics, and Drawings, 3) Sculpture, 4) Ceramics, and 5) Other. There will be several purchase awards and many works will be for sale. The Art Committee's:

Varian Ashbaugh
Barbara Byers
Anne Del Calzo
Jeanne Filter
Kenneth Filter
Herman Jantzen
Jane Kershaw

Joy Kinney
Gene Lang
Luella Morgenthaler
Mary Payson
Irma Polhemus
Vivian Sadin
Rita Zimmerman

LADIES' PROGRAM

The enclosed registration card should also be used for advanced registration for ladies' tours. A special registration desk will be open in the lobby of the Brown Tower Building (across Tremont Place) from 9:00 a.m. to 11:00 a.m. on June 17. Studio Room 843 at the Brown Palace Hotel will be a rendezvous and information room Tuesday thru Friday for the ladies' program. Late arrivals can register in Studio Room 843. Departure for all events will be from the Brown Palace Hotel. Children accompanied by parents are welcome.

Tuesday, June 17 — Leave Brown Palace Hotel at 11:00 a.m. for lunch and fashion show at Larimer Square.

Wednesday, June 18 — Leave Brown Place Hotel at 8.30 a.m. for trip to Vail, Colorado. (Trip to Vail will take approximately 3 hours.) Two hours for shopping at Vail and lunch. Return to Denver at approximately 4:30 p.m.

Thursday, June 19 — Leave Brown Place Hotel at 8:30 a.m. for tour of Air Force Academy. Lunch at Officer's Club. Pikes Peak tour at 1.30 p.m. ending at 4:30 p.m. and proceeding to the Flying W Ranch.

Chuck Wagon Dinner and Show — Flying W Ranch — Thurs. June 19, 7:00 p.m. Thursday evening is an open night for the men. A bus will leave from the Brown Palace to take any of the men who may wish to join the women for dinner. The evening's activity is finished at approximately 9:45 p.m. — Arrive in Denver at approximately 11:00 p.m. Special attention of all women is invited to the First National Space Art Show held in the Central City Room (B) and open from 9 a.m. to 9 p.m. each day.

Chairman: Sue Mumma

Co-Chairman: Donna Baum

MESSAGE CENTER

A telephone message center will be located in the lobby of the Brown Palace Hotel, adjacent to the Registration Desk 9303-825-6388, courtesy Mountain States Telephone Co.)

AAS BOARD MEETING

The AAS Board Meeting will be held at 6:30 pm., Monday June 16, in the Stratton/Tabor room of the Brown Palace. The Annual Business meeting is scheduled for 5:00 p.m., Tuesday June 17, in the Empire room of the Cosmopolitan.

ORSA COUNCIL

The ORSA Council will meet at 1:45 p.m., Tuesday June 17, in the Gold Room of the Brown Palace. The Annual Business meeting will be held at 5:30 p.m., Tuesday June 17, in the Broadway Arms of the Cosmopolitan Hotel. Wednesday afternoon's Council meeting will also be held in the Gold Room.

COST EFFECTIVENESS MEETING

Cost Effectiveness Section meeting will be held Thursday June 19, 1969, 5:00 p.m., in the Holiday Room of the Cosmopolitan. A Section business meeting will be conducted. In addition, Mr. David Novick of the RAND Corporation will present a description of the origins of PPBS.

SOLE MEETING

The Society of Logistics Engineers (SOLE) Conferences will be held 8:30 a.m. to 5:00 p.m., Monday June 16, in the Onyx Room of the Brown Palace.

PRESS ROOM

The Georgetown and Silver Plume Rooms of the Brown Palace will be available for the Press Tuesday thru Friday.

WORKSHOP: WORLD SYSTEMS CENTER

Leadville Room, Brown Palace

Day-long (come-and-go) workshop sessions are planned for Tuesday thru Friday, related to utilization of a World Systems Center for development and management of global systems (Communications, Transportation, Weather Control, Earth Resources, etc). Workshop objectives are to:

- Conduct organized brainstorming sessions in areas of Systems Engineering, Simulation and Engineering Management

- Discuss feasibility for a World Systems Center
- Prepare such outputs as:
 - Flow diagrams of global, national, and local systems
 - Information and data on special forms and matrix type sheets
 - Results of brainstorming sessions
 - Summary results
- Identify problem areas and suggest solutions

Chairman:

Harold B. Secrist, Jr.
McDonnell Douglas Corporation
Huntington Beach, California 92646

Co-Chairman:

George Fosdick
Martin Marietta Corp.
P.O. Box 179, Mail No. 0497
Denver, Colorado 80201

MEETING COMMITTEE

General Program Chairman

G. W. MORGENTHALER
Martin Marietta Corp., Denver

Asst. Chairman AAS

W. KERSHAW
Martin Marietta Corp., Denver

Asst. Chairman ORSA

R. TEGMEYER
Martin Marietta Corp., Denver

AAS Technical Program

S. SADIN
Martin Marietta Corp., Denver

ORSA Technical Program

M. GEICK
Gates Aviation Co., Denver

Special Programs

R. IREY
Martin Marietta Corp., Denver

Theme Sessions

R. BIDDINGER (AAS)
 T. BURNS

Martin Marietta Corp., Denver
 M. CAPEHART (ORSA)

Specialist Sessions

King Resources, Denver
 A. ROTHSTEIN (AAS)

W. BURSNALL (ORSA)

Exhibits

D. DEWEY
Martin Marietta Corp., Denver

Meeting Administration
Arrangements

E. PAYSON
 P. NEUKIRCH

A. SELKE

Printing

R. JONES
 G. WENNER

Mailing

M. TRUBE

Registration

M. O'HERN

Publicity

N. DEL CALZO

Preprints

R. MORRA

Martin Marietta Corp.,
Denver, Colorado

Finance

H. TILLQUIST

C. BUSCH

Mountain States Telephone,
Denver, Colorado

INDEX OF PARTICIPANTS

- ABLAHAT, NEWTON - XIIIB
 ADAMS, J.L. - IE.1
 ADELMAN, IRMA - XIIIB.2
 ADLER, ISIDORE - IIIE.2
 ALEXANDER, H.S. - XIIID.3
 ALLEN, DAVID - VIIF.4
 ALLEN, FRED MARSDEN
 ALLEN, JAMES - XVE
 ALLEN, W.H. - XIIID.2
 ALMGREN, DAVID - VJ.1
 ANAND, SADISH K. - IIIG.4
 ANDERSON, J.E. - IXH, XH,
 XIIH, XIIIH
 ANDERSON, RICHARD R. - VIC.3
 VJ.3
 ANDERSON, SALLY - IVG.2
 ANTHONY, HAROLD - XVIB.3
 ARNETT, J.B. - XVH.2
 ARNOLD, MAURICE D. - VIB.2,
 VIB
 ARORA, S.R. - VIIIF.3
 ARRISON, J.M. - XIVG.3
 ASHOUR, SAID - VB%
 ASIALA, CARL F., Jr. - XIVC.5
 ATCHISON, THOMAS C. - VE, VIE
 ATHERTON, R.R. - XC.1
 AUCREMANNE, M.J. - VIIID.3
 AVIZIENIS, ALGIADAS - XIE.3

 BALDWIN, LIONEL - VIA
 BALDWIN, D.L. - VIIIH.4
 BANATHY, BELA H. - VID.3
 BARGER, A.R. - IIIC
 BARNES, D.A. - VIH.1
 BARRETT, PHILIP A. - IVA.3
 BARRY, J.J. - IIIG
 BARSKY, DONALD T. - VG.3
 BARTER, J.W. - VIIIE
 BARTH, C.A. - IIIC.2
 BATEMAN, WORTH - XIF.2
 BAUER, E.H. - XVC.3
 BAULCH, DeWITT - VIIIB.4
 BEADLES, R.L. - VIIIH.3
 BEARD, D.B. - XIH.2
 BECKER, H.S. - IIIA.1, XIIIC
 BECKWITH, RICHARD E. - VIG
 BEDROSIAN, S.D. - VB.4
 BERRY, CHARLES A.
 BELHORN, LEE - IVD.1
 BELL, J.H., Jr. - IE.3
 BELL, LARRY E. - VA.2
 BELL, COLIN E. - VIIIF.4
 BELL, LLOYD - IIF.3

 BELLESS, R.M. - VIIJ.3
 BELLMORE, MANDELL - IIID.3
 BEN-ISRAEL, A. - IIG.3
 BENNINGTON, GERALD B. - IIID.3
 BENZ, G. - VIIC.4
 BERGST, GEORGE L. - VF, VIF
 BERNSTEIN, PAUL W. - VC.2
 BERRY, C.A. - XIVC.1
 BERTNOLLI, E.C. - VIIIH.5
 BETHUNE, JAMES E. - IIIB.4
 BIDWELL, JEROLD M. - IVC
 BIEMAN, KLAUS - XIA.2
 BILLINGHAM, J.J. - IE.1
 BINNER, PAUL R., Ph.D. - IB.4
 BIXHORN, HERBERT - IVG.3
 BLACK, F. - VD.4
 BLITZ, MELVIN - VH.2
 BLIZARD, J.B. - IIC.4
 BLIZARD, R. - XE
 BLYTHE, RICHARD H. - XVIIE
 BLUM, P.B.
 BOECKER, BARRY - VIG.5
 BOLGER, PHILIP H. - XVIA.5
 BOLTHOUSE, A.S. - XIVG.2
 BOND, RICHARD - XIIIC.5
 BORMAN, FRAND
 BOSCIA, ANGELO J. - VIC.3
 BOWE, J.J. - XIIIJ.4
 BRADFORD, W.C. - XIE
 BRASWELL, ROBERT N. - IIG.2.
 VIG.3
 BRAUNWARTH, C.A. - XVC.4
 BREKKE, ARVID B. - VF, VIF
 BRENEMAN, DAVID - XIVF.1
 BROWN, A. - VIIIG.4
 BROWN, THOMAS A. - IXD.2
 BROWNE, T.P. - IXC.2
 BRUNO, J.E. - XIIIF.3
 BRUNS, H. - VIIF
 BRYANT, TED - XB.2, XB
 BRYK, OLIVER - IIH
 BUCHIN, STANLEY I. - IVH
 BUCKLEY, JOHN L. - IVC.3
 BULAT, JOE - XVID.2
 BURTON, RICHARD M. - XVIF.1
 BURTON, ROBERT W. MAJ. - IIF
 BUTTON, R. - XIVA.1
 BUTTERWORTH, ALLEN V. - XJ

 CADLE, RICHARD D. - XVIB.1
 CAMERON, RUSSELL J. - VIIIB.1
 CAMERON, W.S. - IXH.1
 CAPEHART, MELVIN - IIB

- CARLISLE, RICHARD F. - IVA
 CARO, FRANCIS G. - IB.3
 CARUTH, W.R.B. - XVIG.1
 CARPENTER, JAMES L., JR. - VH.1
 CARTER, DOUGLAS - IIA
 CARUTH, W.R.B. - XVIG.2
 CASE, JAMES H. - XID.2
 CASEY, ROBERT - IIIA.2
 CASH, T.D., JR. - VIG.2
 CERVI, JOHN E. - IXG, XG
 CETINICH, J.N. - IXB.4
 CHAMBERLAIN, ROBERT G. - XVIK.1
 CHAN, S. PARK - VIIIG.3
 CHANG, Y.S. - VIG.7
 CHARLES, MICHEL A. - VIE.2
 CHASSON, ROBERT - IIC
 CHENAULT, ELMER - XVB
 CHIDAMBARAM, T.S. - IIIG.2
 CHIDESTER, A.H. - XIVH.2
 CHOATE, J. - IVE.2
 CHRISTENSEN, D.H. - VIIIB.3
 CHUAN, R.L. - XIIF.1
 CHURCHILL, R.J. - VIIIJ.3, VIIIJ
 CICCIA, NICODEMO A. - VH.2
 CLAUSEN, REID H. - XIE.4
 CLARK, GEORGE W. - IIC.3
 CLARK, JERE W. - VID
 CLARK, J.F. - VIIIB.4
 CLEMENTSON, G.C. - XVIG
 CLOHESSY, WILLIAM H. - XIID
 CLUTTER, JEROME L. - IIIB.4
 COFFEY, JOSEPH I. - XD.1
 COHEN, C.L. - XIIJ.3
 COHEN, ERNEST B. - IXB.1
 COHEN, MICHAEL E. - VIF.1
 COHEN, STEVEN H. - ID.2
 COLE, HUGH M. - IID
 COLWELL, ROBERT N. - IIA.2
 COPE, ROBERT S. - IXG.1
 CORRADO, CAROL - XIIB.1
 COWEN, DAVID L. - XIVB.4
 COX, ROBERT M., JR. - VE.2
 COYLE, M. - VJ.1
 CRABTREE, DR. EDWIN - XVB
 CROCKER, G. - XIVA
 CROW, EDWIN L. - IG
 CRYSTAL, ROYAL A. - XIVB
 CULP, R.D. - VIIJ.1, VIIJ.2
 CUNNINGHAM, ALAN M. - XVD.2
 CUNNINGHAM, WALTER - IIIA.3
 CURRY, R.B. - IXB
 CUSACK, G.M. - XIJ.5
 DAETZ, DOUGLAS - XIG.1
 DALKEY, N.C. - XIIG.3
 DASPIT, LEO - XIIC.2
 DAVIDSON, HAROLD - XVD.3
 DAVIDSON, R.P. - VIIIJ.3
 DAVIS, J.B. - XVIIJ.1
 DAVIS, P.S. - IVF.3
 DAVIS, R.M. - VK.2
 DAVIS, RICHARD M. - XIVD
 DAY, WILLIAM J. - IXB
 de CZEGE, MIKLOS WASS - XVF.4
 DEEMER, WALTER L. - IXD, XD
 DeKIEFFER, ROBERT E. - VID.2
 DELFICO, J.F. - XIID.1
 DEMBLING, PAUL B. - IC.4, IC
 DESSAUER, JOHN - VIH.3
 DEUTSCH, STANLEY - XIVC
 DEVANEY, MICHAEL J. - VIIIH.2
 DEWILDE, P. - VB.3
 DIAMANT, E.S. - IXB.3
 DICKEY, JOHN W. - VIIIF.5
 DISHER, JOHN H. - XVC, XVIK
 DOBIESKI, A.W. - VIIID.2
 DOBRZELECKI, A. - VIIJ.4
 DODDS, J.I. - VK.1
 DOLINSKY, EDWARD L. - XIVB.1
 DOMINY, FLOYD - IVB.2
 DOMINICK, D. - XVB
 DONAGHEY, CHARLES E. - IIIF.2
 DONAHUE, JAMES D. - XJ
 DONALDSON, R.M. - XVD.4
 DORN, WILLIAM S. - IIIF
 DOWNING, M. - XE.4
 DRAKE, RICHARD W. - XVIA
 DRAPER, ALFRED C. - VK
 DRESCHOFF, G. - XIH.1
 DRISCOLL, DAN - XIIC.3
 DROWNS, ROBERT E. - VG.2
 DUBISSON, J.C. - VIIH.2
 DUKE, THOMAS H. - VIIIF
 DUNN, JAMES R. - VIIB.4
 DUVIVIER, J.F. - XIIJ.2
 DWYER, JOHN F. - VH
 DYBWAD, J.P. - XIH.2
 DYNAN, HAL S. - XIIB.3
 ECKMAN, PHILLIP - IXA.3
 EDLER, H.G. - XVIK.3
 EDLER, H.G. - XVIK.4
 EDWARDS, WARD - XIVC.2
 EGGERS, ALFRED, JR. - VIA
 EHRICK, DR. EUGENE - XIHA.1
 EHRICKE, KRAFFT - XIA.2, XIA,
 EISELE, LT. COL. DONN F. - IVA
 ELLIS, J.B. - XIG.2
 ELLIS, R. - XVG.3
 ELLISON, R.W. - VIIIF.2

EMMONS, HAMILTON - VIII G.2
 ENGER, TORLEIV - VC.3
 EPPEN, G.D. - XJ.1
 ERICKSON, FLOYD - VIII E
 ETO, HAJIME - III D.4
 ETTER, DANIEL O., JR. - VIII D.1
 EVANS, JOHN C., JR. - IC.2
 EVERS, WILLIAM H. - VI G.6
 EWALD, EARL - XV B.1

FAGET, MAXIME A. - VI C, VI
 FALAGRADY, R. - XV IF
 FAVERO, MARTIN - XIII C.1
 FEDDERSEN, ALAN P. - XV IF.4
 FEDOROFF, OLEG V. - VIII D.3
 FELDMAN, ART - VC
 FENG, CHUAN C. - VC.3
 FIELDS, S.A. - VE.1
 FINKEL, SEYMOUR I. - VH.3
 FISCHER, WILLIAM A. - II A.1
 FISHMAN, GEORGE S. - IV G.4
 FLEISCHMAN, E.F. - XVC.3
 FORDYCE, SAMUEL W. - XE.3
 FORGOTSON, JAMES M. - XV B.2
 FOSDICK, GEORGE E.
 FOSS, T.H. - XIV H.1
 FOSTER, GLENN G. - XIV G
 FOX, THOMAS G. - XVI G.5
 FOWLER, P.H. - VIII H
 FRANKEL, M.L. - XV B.7
 FRANZGROTE, E.J. - XH.3
 FREEMAN, JOHN R. - VF.3
 FREEMAN, RAOUL,
 FREY, S.C. - XII J.3
 FRIEDLANDER, ALLEN - XA.3
 FRISCH, F.A.P. - XIII J.3, IX J,
 XII J, XII J, XII J.3
 FULLER, G.M. - VK.5
 FULLERTON, D.G. - XIII J.1
 FULTON, GEORGE P. - XV B.3

GAFARIAN, A.V. - IX J.4
 GALLAGHER, G.L. - XV IE.4
 GANGLER, JAMES J. - VII A, IE
 GARDNER, H. - VI H.2
 GARFINKEL, R.S. - II G.4
 GATZKE, H.W. - VIII J.2
 GATTS, J.D. - XI VE.3
 GAVER, DONALD P. - XIV F.2,
 XIV F, XIII F
 GERSHEFSKI, GEORGE W. - IV D.2
 GESSERT, ROBERT A. - VII D, VIII D
 GIEBINK, JERRY - XI VB, VII E
 GILLESPIE, J.R. - XJ.6
 GIVIDEN, GEORGE M. - IF

GLIOZZI, JAMES - VIII A
 GLYNN, P.C. - VIII F.3
 GOLD, THOMAS - VIII A.3
 GOLDEN, C.J. - VIII E.2
 GOLDMAN, A.J. - IX J.5
 GOLDSTEIN, H.A. - IV H.3
 GOLLADAY, FREDRICK L. - XII B.2
 GOODFRIEND, R.D. - XI J.4
 GOODRUM, JOHN C. - VH, VI H
 GOODY, R.M. - II C
 GORDON, B.G. - VB.5
 GRAHAM, B. - XI VA
 GRANT, R.B. - XV ID
 GRAVIER, J.P. - VII J.1
 GRAY, E.Z. - VI A.3
 GREEN, JACK - XH.2
 GREEN, R.R. - IX H.2
 GREEN, W.D. - XVC.1
 GREENBERG, HERBER J. - III F
 GREENBERG, IRWIN - VIII G
 GREENE, STANLEY A. - XI C.1
 GREENING, C.P. - II F.2
 GREENLECK, MERWYN R. - XIV B.3
 GREENSITE, A.L. - XI VE.1, XI VE.4
 GREYBER, HOWARD D. - II C
 GRIFFIN, J. - XI J.5
 GRIFFITH, G.E. - VIII F.3
 GRODOWITZ, WILLIAM - VIII D.4
 GROOVER, PAUL L. - XIII D
 GROSS, D. - IG.2
 GUILD, D.R. - XI E.7
 GUILL, J.H. - XA.1
 GUPTA, S.C. - VI G.2

HABER, S. - IX J.5
 HAEUSSERMANN, WALTER - XVA
 HAIT, M.H. - XIII H.2
 HALBERT, MICHAEL H. - IB.1
 HALEY, R.L. - XIII A.2
 HALL, BRUCE - VII A.2
 HALL, CHARLES F. - IX A.5
 HALL, CLIFFORD J. - VI H.2
 HALL, W.K. - XII J.1
 HALPERN, JONATHAN - XIII F.1
 HAMELMAN, P.W. - XV G.3
 HAMMOND, R.A. - XI G.4
 HANITZSCH, E. - XII J.1
 HAPP, W.W. - XIII J.2
 HARRIS, C.M. - IG.2
 HARRIS, CLARENCE J. - XVII J.2
 HARRISON, COLIN A. - III A
 HARRISON, JOHN T. - VIII F.5
 HASE, PAUL F. - IV H.1
 HASKINS, BARBARA - VIII F.4
 HAURLAN, PETER - IX A

- HAYES, FRED - XF.1
 HAYES, RICHARD J. - XIII.E.1
 HAYNAM, K.W. - VIIIC.2
 HAYS, E.L. - VA
 HAYWARD, CARL B. - VE.2
 HAZONY, D. - VB
 HEARD, R.C. - XVID
 HEATON, THOMAS R. - VIID
 HEDGEPEETH, JOHN M. - VC.1
 HEFFNER, W.A. - VIIIH.1, VIIIG,
 VIIIH
 HEISKALA, V. - IF.1
 HEISS, KLAUSE P. - IVA.4
 HELD, MICHAEL - IIG.1
 HELDENFELS, R.R. - VC
 HELLAND, JOSEPH C. - XIE.1
 HENDEE, WILLIAM - VIIIE
 HENDERSON, G.C. - XVH.2
 HENDRICKS, ERNEST L. - IVB.1
 HENRY, JAMES - IID
 HENRY-LABORDERE, ARNAUD L. -
 IIID.1
 HENSEN, RONALD J. - IXJ, XIIJ,
 XIIJ
 HERMAN, MAJOR ALAN - IC.3
 HERSHKOWITZ, MARTIN - VH.3
 HESPOS, RICHARD - XIIIB
 HESS, WILMOT - IA
 HEYMAN, DANIEL P. - IG.1
 HILTON, HOWARD J. - XIB.1
 HINKLE, CHARLES - IVH
 HINKLE, ROBERT H. - VIF.3
 HISEY, BRADNER L. - VIF.2
 HOAGLAND, J.C. - XIIG.1
 HOEBER, FRANCIS P. - IIIG
 HOFFMAN, A.J. - XVH.2
 HOFFMAN, FRED S. - IXF.2
 HOLDSWORTH, J.R. - VIIIC.3
 HOLECEK, D.J. - XIVE.5
 HOLLENDER, H.A. - IIIE.2
 HOLLISTER, ROBINSON - XIIIF.1
 HOPKINS, DAVID - XIVF.1
 HOPSON, GEORGE D. - VJ.2
 HORN, W.A. - IXB.2
 HORNUNG, J.P. - XVIF.3
 HORNBY, HAROLD - VG
 HOROWITZ, ISAAC M. - VB
 HOUCK, FRANK S. - XD.2
 HOWARD, G.T. - XVIF.1
 HU, STEVE S. - XIII.E.3, XIIIE
 HU, T.W. - XVG.6
 HUGHES, JAMES F. - XIE.2
 HULSTROM, ROLAND L. - IIIC.3
 HULT, J.L. - XE.1
 HUNTER, M.W. - XHA.1
 HUNG, J.W. - IVB.5
 HWA, C.S. - XIB.2
 ICHNIOWSKI, FRANCIS C.J. - XF.4
 IGLEHART, D. - XJ.2
 IKEDA, T. - XJ.3
 INSLEY, C.J., JR. - VH.1
 JAISWAL, N.J. - VIIIG.4
 JAMES, W.E. - XIVE.5
 JEFFERSON, WILLIAM - XVD, XIIIG
 JELMERT, ANDREW - VIIIE.2
 JENKINS, DALE - XIIIC.3
 JENSEN, JORGAN - IXA
 JENSEN, LLOYD T. - XVIB.5
 JEWELL, WILLIAM - ID
 JEZIOR, ANTHONY M. - VIF.3
 JIRACEK, G.R. - IVE.1
 JOHNSON, A.M. - XIVG.2
 JOHNSON, ARNOLD IVAN - IVB
 JOHNSON, C.C. - VA.1
 JOHNSON, C.D. -
 JOHNSON, CHARLES H. - XVJ.1
 JOHNSON, D.D. - VIIIG.4
 JOHNSON, L.H. - IIIG.3
 JOHNSON, R. CURTIS - IIG
 JOHNSON, RODNEY W. - IE
 JOHNSON, MAJOR STUART W. -
 IVE.2, IVE, IIIE
 JONES, MAJ. GEN. DAVID M. -
 IVA.1
 JONES, J. MORGAN - XVIIJ.4
 JORDAN, RUSSELL T. - XIA,
 XIIIC
 KABAK, IRWIN W. - VIIIG.1, IVG
 KAHAN, ARCHIE M. - IVC.4
 KANACKE, THEODORE W. - IVA.2
 KARP, RICHARD M. - IIG.1
 KARAYALCIN, I. ILHAMI - XIIIG.5,
 XIIIG.3, XIIIG.4
 KAUFMAN, ALVIN - VIIIB.2
 KEATE, K.J. - IXC.3
 KELLOG, WILLIAM W. - IVC
 KEMP, M. - IVE.2
 KENNEDY, FRED - VF.2
 KENNEY, J.F. - XIH.3
 KERN, F.J. - VIIIH.5
 KERN, H.P. - XIVA.3
 KERRISK, D.J. - XA.4
 KERSHAW, JOSEPH A. - XIF, XIIIF
 KESTERKE, D.G. - VIE.1
 KETTELLE, JOHN D. - XIVG
 KEVAN, L. - XIIH.1
 KIM, CHAIHO - IVF.2

KIMBLETON, S.R. - XVII.1
 KING, JOHN M. - XII.1
 KINGSLAND, LOUIS, JR. - XVI.1
 KINSLER, MARTIN R. - XIII
 KLEERUP, BERTEL W. - XVD
 KLEINBERG, G.A. - II.1
 KLINKNER, RICHARD - II.3
 KLIR, GEORGE J. - VID.1
 KLOPP, D.A. - VIII.4
 KNAPP, ROBERT W. - XV.4
 KNIGHT, F.D. - III.3
 KNOEDLER, JAMES L. - XIII.6
 KOBER, CARL L. - IA, VII.4
 KOPPL, WERNER - VIII.3
 KOTTENSTETTE, J.P. - XII.3
 KOWALSKY, T.E. - XII.5
 KOZA, RUSSELL C. - II.2
 KUARK, JOHN Y. - XIII.3, XIII
 KUBOKAWA, CHARLES C. - XIII.4
 KUCHARSKI, J.M. - XII.3
 KUMAR, SANTOSH - VB.1
 KUMIN, HILLEL - VIII.3
 KUMMER, W.H. - XE.2
 KUTCHMA, EDWARD K. - III.2

LaFLEUR, JOSEPH D. - IX.3
 LASKY, J.S. - III.5
 LAURINO, RICHARD K. - IXD.1
 LaVITA, JAMES A. - IV
 LAYTON, J.P. - XC.3
 LAZARA, MICHAEL - III.1
 LEA, RICHARD C. - XII
 LEDERER, JEROME - XVIA
 LEIMKUEHLER, F.F. - XII.4
 LENARD, MICHAEL - IX.1
 LEPORE, CHARLES J. - VII
 LESSING, RONALD - IV.1
 LESSO, WILLIAM G. - VI.5
 LEVIN, ROBERT A. - XII.1
 LEVINE, P. - XVE.1
 LIEBENOW, ROBERT C. - III.2, III
 LILLY, DOUGLAS K. - IV.1
 LIMAYE, D.R. - XVII.2, XVII.3
 LINDSEY, WILLIAM C. - XE
 LINLOR, DR. W.I. - IV.1
 LINTON, ROGER C. - VIII.1
 LIPPKE, B.R. - XB.5
 LIPPMAN, S.A. - XII.1
 LLOYD, JOHN T. - VK.4
 LO, A.W. - XII.3
 LOGSDON, JOHN - XVE.2
 LONG, J.E. - IX.4
 LORCK, HORACE C. - VIII.3
 LORSCH, HAROLD G. - VII.3
 LOVE, EUGENE - XII.1

LOWE, HARRY N. - VII.2
 LUBORE, STEPHEN H. - III.3
 LUCAS, WILLIAM - XI.1
 LYNN, N.S. - XV.3

MACHESNEY, J. DOUGLAS - XVI.3
 MACKEN, DONALD R. - VIII
 MADYDA, ALEX L. - VII.1
 MAGGIN, BERNARD - XI.2
 MANDELL, HUMBOLDT C. - XIV
 MANELLA, GENE - VIII, VII
 MANELLA, GENE - VII, VII
 MANHEIM, M.L. - XII.4
 MANN, DANN - VH.4
 MANN, STUART H. - II.3
 MANNING, L. - VIII.5
 MARAN, STEPHEN P. - II.2
 MARCHAL, C. - VII.2, VII.1
 MARCOTTE, P.G. - IX.2
 MARLATT, WILLIAM - XIII
 MARSHALL, KNEALE T. - XV.1
 MARTIN, J. - XII.2
 MARTIN, JAMES S., JR. - IX.4
 MARTIN, JOHN H. - IX
 MARTINO, MAJ. JOSEPH P. - XII
 MASON, GERALD E. - XI.3
 MASTERSON, JOHN E. - IV.2
 MASURSKY, HAROLD - VIII.1,
 IX, XH
 MATSA, S.M. - IX.2
 MATTHERN, ROBERT O. - II
 MATTHEWS, HOWARD F. - IX.5
 MAXWELL, MAJ. GEN. J.C. - XB.1, XB
 McALLISTER, DONALD F. - XII.4
 McCARTHY, T.J. - XIV.3
 McCORKLE, JOHN M. - XV, XVI
 McCOWN, JAMES W. - XI.3, XI
 McFARLAN, F. WARREN - XII, XII.4
 McFARLAND, MARVIN - XII
 McGETCHIN, CAPT. THOMAS K. - III.1,
 IV.2
 McKAY, L.M. - XIV.2
 McKOWEN, PAUL - VH.4, VII
 McMANN, HAROLD J. - XII.2
 McMILLAN, CLAUDE - XI
 McNICHOLS, GERALD M. - XII.1
 MEIER, W.L., JR. - VD.2, III.1
 MERRIFIELD, ROBERT B. - XVE.3
 MERRY, PAUL - XV
 MICHELSEN, WILLIAM R. - XC.2
 MIERCORT, FREDERICK A. - VI.4, IG.2
 MILLER, B.P. - XV.5
 MILLER, PAUL R. - IE.2
 MITCHELL, H.A. - XE.4
 MITCHELL, J.L. - VII.3, VII.3

- MODI, JAMSHED - VIII.1, VIII.3
 MODLIN, C.T. - VIIF.3
 MOE, MAYNARD L. - VID
 MOFFETT, THURBER J. - IXG, XG
 MOLLOY, R.J. - VIIA
 MONAHAN, T.I. - XIIG.2
 MONTALBANO, M. - IIIF.4
 MONTGOMERY, L.C. - XVIA.3
 MOOD, ALEXANDER M. - XVF.2
 MOODY, LELAND A. - XVID.1
 MORGAN, RICHARDS ORD - XVA
 MORGENSTERN, OSCAR - IVA.4
 MORRIS, MANUEL L. - VIC.1
 MORSE, HAROLD - IB, IB.5
 MORSE, JEROME G. - IIA
 MOSBAEK, ERNEST J. - XIIG
 MOSBRUGER, D. - IVE.2
 MOSELEY, VICTOR A. - IXC.1
 MOSS, JUDITH - VIIIB.5
 MOTTLEY, CHARLES - VIIIB.3
 MUELLER, HEINZ - XC, XIIA, XIIA.2
 MUKHERJEE, SHISHIR K. - IVB.3
 MULLER, P.M. - XIIII.1
 MUMMA, GEORGE B. - XVIA.4
 MUNJAL, P.K. - IXJ.3, IXJ.4
 MUSHKIN, SELMA J. - IXF.1
 MYERS, A.J. - VIIH
 MYERS, DONALD A. - XIVE.2
- NANDA, VED P. - IC.1, IC
 NATHANSON, DANIEL - VJ.1
 NAU, RICHARD A. - VK.3
 NEALE, D.J. - VG
 NEIN, M. - VIIID.6
 NEISS, JOSEPH A. - VIIIE.1
 NEMHAUSER, G.L. - IIG.4, XIJ.3, IIG
 NELSON, R. - XIIC.4
 NERI, J. - VIIH.2
 NEU, EMIL C. - VIIIG.5
 NEUNER, G. - VIIH.3
 NEUKIRCH, PETER H. - IIIG.1
 NEWCOMB, R.W. - VB.3
 NEWMAN, ROBERT - IVD.3
 NODBERK, WILLIAM - XIII A
 NOLEN, JAMES H. - IIIF.1
 NOREM, PHILIP - XIIA.3
 NORMAN, DAVID G. - XIIIIE.3
 NOVICK, DAVID - IXF, XF
 NOVOSAD, ROBERT S. - IIID
- OBERBECK, THOMAS E. - VIJ
 OLIVER, ROBERT M. - XIIIF.2
 XIVF.3, XVF
 OLIVIER, J.R. - VIIID.6
 OLSON, LEE - IIIB
- O'NEIL, W.D. - VIIIC.3
 ORAVEC, RALPH - XVD.1
 ORDAHL, DOUGLAS - IXC.4
 OYAMA, VANCE - XIA.3
 O'ROURKE, G. - VH.2
- PACKER, ARNOLD H. - VF.1
 PAHL, J. - IXJ.4
 PAUL, F. - VIIF.4
 PALMER, EDWARD H. - IIB.1
 PALUDAN, CHARLES T.N. - XVA.1
 PARK, A.B. - IIA.4
 PARKINS, GEORGE - ID
 PATCHETT, ROBERT A. - VIIID.3
 PATTERSON, J.H. - XH.3
 PAULSEN, REX E. - XIIG
 PAYNE, WILBUR - IID
 PEARSON, P.M. - XIJ.2
 PEGELS, C. CARL - VIIIE.2
 PEIRSON, R.C. - VIIIH.5
 PENN, ALLAN - XID.3
 PERNICKA, J.C. - VIIH.2
 PETERMAN, WILLIAM A. - ID.2
 PETERSON, G.L. - XVG.2, XVG.3
 PHILLIPS, PAUL B., Gen. (Ret.) - IID
 PIERCE, JOHN F. - IIID.5
 PINKEL, IRV - XVIA.2
 PIPES, L.A. - IXJ.3
 PLYMALE, D.S. - XJ.4
 POLLOCK, S.M. - IIF.5, IIF
 POWERS, K.H. - XIVA.3
 PRATT, L.I.P. - VIIID.6
 PREHODA, ROBERT W. - XIIG.4
 PRICE, GEORGE - VIB
 PRICE, IRWIN - XVIB.6
- QUEST, R.G. - VK.5
 QURAISHI, M.N. - VB.5
- RABITCH, HERMAN - IF.2
 RAO, S. SUBBA - VIIIG.4
 RASOOL, S.I. - IIIC.1
 RAY, T.L. - IVF.3
 RAYMES, F. - VK.1
 REA, DONALD - XIA.4
 REGELSON, LILLIAN - XIF.1
 REGENBRECHT, D.E. - VJ.4
 REIFF, GLENN A. - IIC.1
 REISERT, R.D. - XVID.4
 RENNELS, DAVID A. - XIE.3
 REX, P.S. - VIIID.6
 RHODES, BEN T., SR. - XIID.5
 RICE, R. - VIIIB
 RICHARDS, LUDIE - IIIA

- RICHTER, H.J. - XIVE.2
 RIEHL, C.M. - ID.1
 ROBERS, P. - IIG.3
 ROBERTS, DAVID L. - XA.2
 ROBERTS, W.T. - VIIIJ.4
 ROBERTSON, L.M. - XVB
 RODNEY, G. - VA
 ROEPKE, W.W. - VE.1
 ROGERS, PETER - IVB.4 VIIIF.1
 RONCA, L.B. - XIH, XIH
 ROSE, ROBERT F. - IXC
 ROSS, DONALD M. - XIIC.2
 ROSS, L.W. - XVB.3
 ROSS, SHELDON M. - IIF.4
 ROTH, C.A. - IXJ.2
 ROZA, RUSSELL C. - HB.2
 RUDY, M.F. - XVA.2
 RUEFLI, TIMOTHY W. - XID.4
 RUSSAK, SIDNEY L. - XA.3, XVE
 RUTLAND, CAREY - XIVD.3
 RUTTENBERG, S. - VIID.4
 RYAN, J.A. - VE.1
 RYAN, PETER C. - IIID
 RYBAK, J.P. - VIIIJ.3

 SAARI, J.M. - XIH.3
 SAFFRAN, G. THEODORE - VF.4
 SAGEN, OSWALD K. - XIVB.2
 SAKSENA, J.P. - VB.1
 SANDERSON, ROBERT - XVF.3
 SARKISIAN, EDWARD - VIIG.1, VIIIH
 SATSANGI, P.S. - XIG.2
 SAVAGE, M. - VIIF
 SCHERER, CAPT. LEE - VIIA
 SCHIAGER, DR. KEITH J. - XVIB.2
 SCHICK, ALLEN - XF.2
 SCHOENHALS, R.J. - XIIC.4
 SCHORR, MARVIN - IID
 SCHOW, HORACE, II - VG.4
 SCHULMAN, FRED - IXE.4
 SCHULTZ, ROREN A. - XIIE.3
 SCHUMACHER, ERNEST A. - VIC, VJ
 SCOTT, R.F. - XIH.1
 SECRIST, H.B. -
 SENGUPTA, S.S. - XIG.2
 SHAIN, R.B. - XVG.1
 SHANNON, R.E. - IIIG.3
 SHAPIRO, JACOB - VA.3
 SHAPIRO, LEO - IIB
 SHAPLEY, LLOYD - XID
 SHAY, J.R. - IIA.3
 SHEFFIELD, KENNETH - XVJ.3
 SHEGDA, MICHAEL - IVD
 SHERMAN, G.R. - VIG.1
 SHERMAN, J.W. - IIA.5
 SHETTY, C.M. - VIG.2
 SHORT, N.M. - IXH.3
 SHOTTS, RAYMOND Q. - VE.2
 SILVER, AARON N. - VIG
 SINGER, S. FRED - IVB, VIA.1
 SJOGREN, W.L. - XIH.1
 SKARTVEDT, GARY - IXC
 SKARTVEDT, COL. P.S. - XIID.4
 SLOOP, JOHN - VIA.2
 SLYE, ROBERT E. - VIIIIE.3
 SMITH, ARVIN H. - IXE.2
 SMITH, DENNIS E. - XIG.3
 SMITH, DOUGLAS V. - IVB.4
 SMITH, FRANK - VIIIB
 SMITH, G.E. - XIIG.1
 SMITH, G.S. - XIVA.2
 SMITH, GEORGE W. - XIIIIE, XVJ, XIVE
 SMITH, HENRY J. - IA.1
 SMITH, LEE H. - XVIIJ.3
 SMITH, MELVIN R. - IVG
 SNYDER, MARTIN A. - IIF.1
 SOBEL, MATTHEW J. - XIIG.2
 SOFFEN, GERALD - XIA.1
 SOHONI, V.S. - XIIE.7
 SOLAND, RICHARD M. - VIG.4
 SONNABEND, DAVID - XA
 SOVEREIGN, M.G. - VIIF.2
 SPARVERO, L.J. - XIG.5
 SPOHN, CLIFF - XIII.3
 SPOND, D.E. - XIIIJ.1
 STAHL, FREDERICK G. - XIVG.1
 STAMPER, J.C. - XVIE.4
 STANFORD, ROBERT - XIVF.3
 STEINBRUNER, JOHN D. - XIID.2
 STEINER, JACK - XB.4
 STEINHOFF, ERNST - VIIIA.2
 STEINITZ, CARL F. - VIIIF.1
 STEPHENS, JAMES R. - XIIE
 STEPHENS, PAUL - VIC.2
 STERHARDT, JAMES A., JR. - VK
 STEPUTIS, F.J. - VIID.6
 STERN, J. - XIIC
 STERRETT, J.K. - VIIJ
 STEWART, J.R. - XB.5
 STIMSON, DAVID H. - XVIB.6
 STINSON, PERRI - VD, XID
 STOCKING, W.P. - VB.3
 STOLLER, DAVID S. - IB
 STONE, HERBERT - VD.3
 STONE, LAWRENCE D. - IIF.1
 STREET, ROBERT L. - XVIF.2
 STRING, JOSEPH - XIVD.1
 STROM, R.G. - XH.1

- STUBBS, DAVID W. - XIVC
 SUICK, J.E. - IIIF.3
 SULLIVAN, EDWARD F. - XVG.5
 SWAN, DR. GORDON - XIIIH,
 XIVH, XVH
 SWENSEN, G.R. - VIIIJ.5
 SWET, C.J. - VIIIC.2

 TALKINGTON, JOE E. - XG.1
 TAYLOR, CALVIN W. - XIVC.3
 TEGMEYER, R.C. - VIJ
 TEPPER, MORRIS - VIID.4
 TEWELL, J. ROBERT - XVJ.1
 THAKUR, SUNDER S. - VIG.6
 THEIL, HENRI - XIIIH
 THOMAS, A.A. - IIE.1
 THOMAS, CLAYTON J. - XIID.1,
 XIID
 THOMAS, MICHAEL E. - XVIG.1
 THOMAS, SHIRLEY - VIIIH.2
 THOME, PITT G. - XA, IXA.1
 TIFFANY, O. LYLE - VIIA.1
 TILLQUIST, H.R. - IVD
 TISCHLER, ADELBERT O. - XC
 TITUS, RICHARD R. - XVC.2
 TOBEY, W.H. - XVJ.2
 TREYNOR, J.L. - IVD.4
 TROLLINGER, WILLIAM V. - XVA.3
 TROPF, W.J. - VG.4
 TRUJILLO, ROBERT D. - IB.2
 TUEY, R.C. - XIVD.4
 TURKEVICH, A.L. - XH.3
 TURNEY, H.W., JR. - XIIE.5

 UCHILL, SHERMAN - IVH.2
 UHLANER, J.E. - IF.1
 UPDERGRAFF, D.M. - IIIB.3

 VADEBONCOEUR, J.R. - IXB.3
 VAN VLECK, E.M. - VIIIE.2,
 XVIK.2
 VAUGHAN, DESMOND H. - VC.4
 VAZSONYI, ANDREW - ID.3
 VINH, N.X. - VIIJ.4
 VOGELY, WILLIAM A. - VIIH
 von KAAAN, CLIFTON - XB.3

 WADE, D.C. - VIIF.3
 WAGNER, JOHN T. - XIIE.4, VIIJ.3
 WAITE, JACK H. - VIID.1
 WALKER, GERALD J. - XIIE.1
 WALKER, WAYLAND J. - XVIB.4
 WALLACE, D.A. - VIIG.1
 WALLACE, WILLIAM A. - VIIH.4
 WALTON, J.M. - VIIJ.2
 WANG, C.F. - XVID.5

 WARD, S.H. - IVE.1
 WASEL, R. - IXC.5
 WATKINS, J.S. - XVH.1
 WATSON, IRA A. - XIIB.2
 WEBER, L.L. - VIIJ.5
 WEBER, R.B. - XIVE.3
 WEDEL, ROGER K. - VIC.1
 WEIDNER, D.K. - VIIIJ.1, VIIIJ.2
 WEIGAND, HEINRICK J. - XIC
 WEISS, IRVING - IG
 WEINER, MILTON G. - XIID.3
 WEITZ, HAROLD - XVG.4
 WETMORE, WILLIAM H. - XIC.4
 WHEELER, A.C. - XJ.5
 WHITBY, THOMAS - XIB
 WHISNANT, J.M. - VIIIC.2
 WHITE, ARTHUR F., JR. - VIID.2
 WHITEHOUSE, G.E. IXJ.2
 WHITESELL, WILLIAM J. - XIIE.2
 WHITMAN, W.W. - XVII
 WHITSETT, MAJOR C.E. - XIVE,
 XVJ, XVJ.2
 WIEDEMANN, R.E. - IVB.6
 WIGGERS, GEORGE F. - XIJ.1
 WILD, JACK W. - XVIA.1
 WILDE, DOUGLAS T. - VD.1, IVF
 WILKINSON, W.L. - VB.2
 WINSLOW, R. - IF.3
 WINTER, E.R.F. - XIIC.4
 WINTERBERG, F. - XVE.5
 WISE, D.U. - VIIA.3
 WITHERSPOON, J.T. - XJ.5
 WITTRY, LT. COL. JOHN - XIIE
 WONG, R.E. - VIIID.2
 WOOD, E.C. - XIE
 WOOD, K.D. - XIIIJ
 WOOD, R.S. - IIIF.3
 WOODWARD, HARRY R. - VIB.1
 WOODWARD, WILLIAM H. - IXE.1, IXE
 WORRALL, R.D. - XVG.2, XVG.3
 WORTZ, EDWARD C. - XIVC.4
 WRENCH, E.H. - XIVE.4
 WRIGHT, G. - XJ.3
 WROBEL, J.R. - XA.4
 WUDELL, A.E. - XVJ.2
 WUENSCHER, HANS F. - VC.5, XVA.4

 YOUNG, A. THOMAS - IXA.4
 YOUNG, H. - VIIG.4
 YOUNG, RICHARD - XIA

 ZALDIVAR, MIGUEL F. - VF.3
 ZELLER, E.J. - XIIIH.1,
 XIIIH, XVH, XVIIH
 ZIEMBA, W.T. - IVF.1
 ZOBRIST, GEORGE W. - VIIIH.2
 ZUSMAN MORRIS I - VG.1

TUESDAY, JUNE 17

(B) - BROWN PALACE HOTEL
(C) - COSMOPOLITAN HOTEL

8 30	OPENING SESSION SILVER GLADE (C) CALL TO ORDER - GEORGE W. MORGENTHAUER WELCOME - GOVERNOR LOVE (INVITED) KEYNOTE SPEAKER Capt. W. M. SCHIRRA				
9 00	IA FUTURE MANNED AND AUTOMATED EARTH ORBITAL SCIENCE MISSIONS CH: Wilmut Hess CENTURY (C)	IB MANAGEMENT OF SOCIAL INSTITUTIONS - PENAL, WELFARE, EDUCATION, JOB TRAINING CH: David S. Staller BALLROOM (B)	IC SPACE LAW CH: Paul B. Dambling BONANZA (C)	ID DECISION THEORY CH: William Jewell EMPIRE (C)	IE (WGER I) FACILITY DESIGN CONSTRUCTION, & OPERATION CH: Rodney W. Johnson ONYX (B)
	IF MILITARY OR I FIELD EXPERIMENTATION CH: George M. Givenden BROADWAY ARMS (C)		IG ADVANCES IN STOCHASTIC PROCESSES CH: Edwin L. Crow HOLIDAY (C)		
10 15	IIA EARTH ORBITAL RESOURCE MISSIONS CH: Douglas Carter CENTURY (C)	IIB MANAGEMENT OF POPULATION CH: Leo Shapiro BALLROOM (B)	IIC ASTROPHYSICS AND INTERPLANETARY EXPERIMENTS CH: Robert Chesson STRATTON/TABOR (B)	IID MILITARY OR II (PANEL) RELATIONSHIPS BETWEEN MILITARY USERS AND OR PRACTITIONERS CH: Hugh M. Cole HOLIDAY (C)	IIE (WGER II) SUBPROGRAM ON BIOTECHNOLOGY AND HUMAN FACTORS CH: Robert O. Mathern ONYX (B)
	IIF SEARCH AND SURVEILLANCE MODELS CH: Stephen Pollock EMPIRE (C)		IIG LINEAR PROGRAMMING CH: George Nemhauser BONANZA (C)		
12 00	LUNCHEON MC R. FREEMAN APOLLO - A REALITY, COL. FRANK BORMAN SILVER GLADE (C)				
1 45	IIIA LARGE SPACE STATIONS, SPACE LOGISTICS, AND RESCUE (SOLE) CH: Lodie Richards CENTURY (C)	IIIB MANAGEMENT AND EXPANSION OF FOOD AND FOREST RESOURCES CH: Robert C. Liebenow BALLROOM (B)	IIIC PLANETARY SCIENCES AND EXPERIMENTS CH: R. M. Goody STRATTON/TABOR (B)	IIID INTEGER PROGRAMMING AND APPLICATIONS CH: Robert S. Navasod BONANZA (C)	IIIE (WGER III) SUBGROUP ON ENVIRONMENT AND RESOURCES APPLICATIONS CH: Maj. Stuart W. Johnson ONYX (B)
	IIIF ADVANCES IN COMPUTER SCIENCES CH: Herbert J. Greenberg EMPIRE (C)		IIIG ALLOCATION OF R&D RESOURCES CH: Francis P. Hoerber CORONET (B)	IIIH COST EFFECTIVENESS SECTION PANEL A CRITICAL REVIEW OF METHODS OF PUBLIC CHOICE CH: Oliver Bryk HOLIDAY (C)	
3 15	IVA FUTURE RANGES, SPACEPORTS, AND COMMAND CONTROL NETS CH: Lt. Col. Donn F. Eisele CENTURY (C)	IVB MANAGEMENT AND EXPANSION OF WATER RESOURCES CH: S. Fred Singer BALLROOM (B)	IVC ATMOSPHERIC AND METEOROLOGICAL SCIENCE - I CH: William W. Kellogg STRATTON/TABOR (B)	IVD FINANCIAL MODELING CH: Michael Shagdo CORONET (B)	IVE (WGER IV) SUBGROUP ON ENVIRONMENT AND RESOURCES CH: Maj. Stuart W. Johnson ONYX (B)
	IVF NONLINEAR PARAMETRIC AND STOCHASTIC PROGRAMMING CH: Douglas T. Wilda BONANZA (C)		IVG MONTE CARLO AND SIMULATION CH: Irvin W. Kekuk HOLIDAY (C)	IVH OR MARKETING APPLICATIONS CH: Stanley I. Buchin BROADWAY ARMS (C)	
5 00	AAS BUSINESS MEETING 5 00 - 5 30 EMPIRE (C)	SPACE MOVIES 5 00 - 6 00 CENTURY (C)	ORSA BUSINESS MEETING 5 30 - 6 00 BROADWAY ARMS (C)		
AAS HONORS NIGHT BANQUET 6 30 COCKTAILS 7 30 DINNER SILVER GLADE (C) MC: GEORGE W. MORGENTHAUER SPEAKER TO BE ANNOUNCED					

NOTE WGER - WORKING GROUP ON EXTRATERRESTRIAL RESOURCES

WEDNESDAY, JUNE 18					(B) - BROWN PALACE HOTEL (C) - COSMOPOLITAN HOTEL
8 30	VA SPACE ECOLOGICAL TECHNOLOGY AND HUMAN FACTORS (AIBS) CH Edward L. Hays CENTURY (C)	VB NETWORK FLOW THEORY CH D. Hozany HOLIDAY (C)	VC SPACECRAFT MATERIALS, STRUCTURES & MECHANISMS CH R R Haldenfels BONANZA (C)	VD DYNAMIC PROGRAMMING CH Richard Bellman BROADWAY ARMS (C)	VE (WGER V) SUBGROUP ON MINING AND PROCESSING CH Thomas C. Atchison ONYX (B)
	VF HEALTH SECTION - I CH George L. Bergst EMPIRE (C)		VG COSTING TECHNIQUES AND MODELS CH Harold Hornby BALLROOM (B)	VH LOGISTICS PLANNING TECHNIQUES - I CH John C. Goodrum STRATTON/TABOR (B)	VJ SPACECRAFT DESIGN THERMAL SYSTEMS-I CH Maxime A. Faget CORONET (B)
	VIA MOTIVATION AND TECHNOLOGY FOR FUTURE MANNED PLANETARY MISSIONS CH Alfred Eggers, Jr CENTURY (C)	VIB MANAGEMENT OF RECREATIONAL, WILDLIFE, AND CULTURAL RESOURCES CH George Price BALLROOM (B)	VIC SPACECRAFT DESIGN THERMAL SYSTEMS - II CH Maxime A. Faget CORONET (B)	VID CYBERNETICS IN EDUCATION CH Jane W. Clark BONANZA (C)	VIE (WGER VI) SUBGROUP ON MINING AND PROCESSING CH Thomas C. Atchison ONYX (B)
	VIF HEALTH SECTION - II CH George L. Bergst EMPIRE (C)		VIG OPTIMUM ALLOC MODELS AND CASE STUDIES CH Richard E. Beckwith BROADWAY ARMS (C)	VIH LOGISTICS PLANNING TECHNIQUES - II CH John C. Goodrum STRATTON/TABOR (B)	VIJ REPORT OF ORSA LONG RANGE PLANNING COMMITTEE CH Thomas E. Oberbeck HOLIDAY (C)
12 00	LUNCHEON 12 00 - 2 30 R. BUCKMINSTER FULLER - THE WORLD GAME PANEL Charles Haas - Bryghte D. Godbold William Leor - Jonas E. Salk, M.D. William Wolf SILVER GLADE (C)				
2 30	VIIA FUTURE LUNAR MISSIONS CH Capt Lee Scherer CENTURY (C)	VIIIB MANAGEMENT OF MINERAL RESOURCES CH William A. Vogely BALLROOM (B)	VIIIC MILITARY OR III CH Robert A. Gessert STRATTON/TABOR (B)	VIIID SPACE EXPERIMENTS AND SENSORS - I CH Gene Monnello EMPIRE (C)	VIIIE OPERATIONS RESEARCH IN MEDICAL SYSTEMS PLANNING CH William Handee BONANZA (C)
	VIIIF SPACECRAFT TEST DEVELOPMENTAL AND SIMULATION CH Melvyn Savage HOLIDAY (C)		VIIIG AUTOMATED DIAGNOSTIC TESTING TECHNIQUES-I CH Edward Sarkisian ONYX (B)	VIIIH SPACECRAFT RELIABILITY AND QUALITY CONTROL & CHECKOUT CH Peter H. Fowler CORONET (B)	VIIJ FLIGHT MECHANICS AND FLIGHT DYNAMICS CH John K. Storrett BROADWAY ARMS (C)
	VIIIA (WGER) USE OF EXTRATERRESTRIAL RESOURCES CH James J. Gangler CENTURY (C)	VIIIB MANAGEMENT OF LAND USE, URBAN PLANNING, AND HOUSING CH Frank Smith BALLROOM (B)	VIIIC SPACE EXPERIMENTS AND SENSORS - II CH Gene Monnello EMPIRE (C)	VIIID MILITARY OR IV CH Robert A. Gessert STRATTON/TABOR (B)	VIIIE SPACECRAFT COST ANALYSIS CH Floyd Erickson CORONET (B)
	VIIIF NEW APPLICATIONS OF OR CH Thomas H. Duke BONANZA (C)		VIIIG QUEUEING THEORY AND APPLICATIONS CH Irwin Greenberg HOLIDAY (C)	VIIIH AUTOMATED DIAGNOSTIC TESTING TECHNIQUES - II CH Edward Sarkisian ONYX (B)	VIIJ ATMOSPHERIC AND METEOROLOGICAL SCIENCES - II CH R. J. Churchill BROADWAY ARMS (C)
ORSA BANQUET 6 30 COCKTAILS 7 30 DINNER		SILVER GLADE (C) MC Thomas Caywood SPEAKER JOSEPH H. ENGEL COMSAT CORP PRESIDENT OF ORSA		VK FUTURE ENTRY SYSTEMS (CLASSIFIED SESSION) 8 30 - 11 00 AM MARTIN MARIETTA CORP. FACILITY (SEE PROGRAM FOR DETAILS)	

THURSDAY, JUNE 19					(B) - BROWN PALACE HOTEL (C) - COSMOPOLITAN HOTEL
8 30	IXA AUTOMATIC PLANETARY PROBES CH Peter Hourlan CENTURY (C)	IXB SURFACE TRANSPORTATION AND DISTRIBUTION SYSTEMS CH R B Curry BALLROOM (B)	IXC PROPULSION AND ATTITUDE CONTROL SYSTEMS CH Robert F. Rose EMPIRE (C)	IXD ARMS CONTROL I CH Walter L. Deemer BONANZA (C)	IXE FUTURE SPACE POWER CH William H. Woodward CORONET (B)
	IXF PPBS AT FEDERAL, STATE & LOCAL LEVELS I CH: David Novick HOLIDAY (C)		IXG COMPUTER GRAPHICS - I CH Thurber J. Moffett GOLD (B)	IXH LUNAR SURFACE GEOLOGY - I CH Harold Masursky ONYX (B)	IXJ TRANSPORTATION SCIENCES SECTION - I CH F. A. P. Frisch STRATTON/TABOR (B)
10 15	XA UNMANNED COMETARY, ASTEROID, AND INTER-PLANETARY PROBES CH Pitt Thome CENTURY (C)	XB AIR TRANSPORTATION AND DISTRIBUTION SYSTEMS CH Maj. Gen. J. C. Maxwell BALLROOM (B)	XC ADVANCED PROPULSION CH Adelbert O. Tschler EMPIRE (C)	XD ARMS CONTROL - II CH Walter L. Deemer BONANZA (C)	XE SPACE TELECOMMUNICATIONS CH William C. Lindsey CORONET (B)
	XF PPBS AT FEDERAL, STATE & LOCAL LEVELS II CH David Novick HOLIDAY (C)		XG COMPUTER GRAPHICS - II CH Thurber J. Moffett GOLD (B)	XH LUNAR SURFACE GEOLOGY - II CH J. E. Anderson ONYX (B)	XJ MODELING OF INVENTORY SYSTEMS CH Allen V. Butterworth STRATTON/TABOR (B)
12 00	OPEN				
1:45	XIA SEARCH FOR EXTRA-TERRESTRIAL LIFE AND EXOBIOLOGY (AIBS) CH: Richard Young CENTURY (C)	XIB THE COMING INFORMATION EXPLOSION LIBRARY AND INFORMATION MANAGEMENT CH Marvin W. McFarland BALLROOM (B)	XIC ADVANCED UPPER STAGES CH Heinrich J. Weigand CORONET (B)	XID GAME THEORY AND APPLICATIONS CH Lloyd Shapley GOLD (B)	XIE ONBOARD DATA MANAGEMENT CH: W. C. Bradford EMPIRE (C)
	XIF COST EFFECTIVENESS SECTION, POVERTY STUDIES - I CH Joseph A. Kershaw HOLIDAY (C)		XIG OR APPLICATIONS IN ECONOMICS CH Ernest J. Masboeck BONANZA (C)	XIH LUNAR SURFACE ENVIRONMENT - I CH Luciano B. Ronce ONYX (B)	XIJ TRANSPORTATION SCIENCES SECTION - II CH: F. A. P. Frisch STRATTON/TABOR (B)
3 15	XIIA BEYOND THE SOLAR SYSTEM CH: Krofft Ehrcke CENTURY (C)	XIIB FINANCING, MARKETING, AND ADVERTISING FOR RESOURCE DEVELOPMENT CH: Newton Ablehar BALLROOM (B)	XIIC ADVANCED LAUNCH VEHICLE AND UPPER STAGE TECHNOLOGY CH: Harold S. Becker CORONET (B)	XIID GAMING CH: Clayton J. Thomas GOLD (B)	XIIE GUIDANCE, CONTROL, AND NAVIGATION CH: Steve S. Hu EMPIRE (C)
	XIIF COST EFFECTIVENESS SECTION POVERTY STUDIES - II CH Joseph A. Kershaw HOLIDAY (C)		XIIG FORECASTING TECHNOLOGICAL CHANGE CH Maj. Joseph P. Martino BONANZA (C)	XIIH LUNAR SURFACE ENVIRONMENT - II CH: J. E. Anderson ONYX (B)	XIIJ TRANSPORTATION SCIENCES SECTION - III CH: F. A. P. Frisch STRATTON/TABOR (B)
5 00	COST EFFECTIVENESS SECTION BUSINESS MEETING HOLIDAY (C)				
	CHUCK WAGON DINNER AND SHOW - FLYING W RANCH A BUS WILL LEAVE FROM THE BROWN PALACE HOTEL THURSDAY AFTERNOON (See the Program for details)				

FRIDAY, JUNE 20					(B) - BROWN PALACE HOTEL (C) - COSMOPOLITAN HOTEL
8 30	XIIIA SPACE APPLICATIONS WEATHER AND NAVIGATION CH William Nordberg CENTURY (C)	XIIIB NATIONAL ECONOMIC PLANNING CH Henri Threl BALLROOM (B)	XIIIC SPACE BIOLOGY AND STERILIZATION (AIBS) CH J. Stern STRATTON/TABOR (B)	XIIID ORSA SPACE SCIENCE I- LONG DURATION SPACE- CRAFT SATELLITES, AND LOGISTICS CH Martin R. Kinsler EMPIRE (C)	XIIIE ASTRONAUT ACTIVITIES AND SPACE TOOLS I CH Maj. C. E. Whitsett, Jr BONANZA (C)
	XIIIF OR IN EDUCATION I CH Donald P. Gaver CORONET (B)	XIIIG COMMERCIAL OR APPLICATIONS - I CH William R. Jefferson BROADWAY ARMS (C)	XIIH LUNAR GEOLOGICAL EXPERIMENTS - I CH Gordon Swan ONYX (B)	XIIJ MAINTAINABILITY AND RELIABILITY - I CH K. D. Wood GOLD (B)	
10 15	XIVA SPACE APPLICATIONS COMMUNICATIONS AND DATA TRANSFER CH Beardsley Graham CENTURY (C)	XIVB MANAGEMENT OF HEALTH RESOURCES CH Royal A. Crystal BALLROOM (B)	XIVC SPACE MEDICINE AND HUMAN FACTORS (AIBS) CH Stanley Deutch STRATTON/TABOR (B)	XIVD ORSA SPACE SCIENCES - II NASA COSTING TECH- NIQUES AND THEIR AP- PLICATIONS CH Humboldt C. Mandell EMPIRE (C)	XIVE ASTRONAUT ACTIVITIES AND SPACE TOOLS - II CH Maj. C. E. Whitsett, Jr BONANZA (C)
	XIVF OR IN EDUCATION - II CH Donald P. Gaver CORONET (B)	XIVG FIELD TESTING OF OR MODELS CH John D. Kettelle BROADWAY ARMS (C)	XIVH LUNAR GEOLOGICAL EXPERIMENTS - II CH E. J. Zeller ONYX (B)		
12 00	LUNCHEON MC EUGENE KONECCI - PRESIDENT AAS PANEL THE FUTURE OF THE SPACE PROGRAM Moderator - Eugene Konecci Sen Gordon Allott (Invited) Congressman - George Miller Congressman - Wayne Aspinall (Invited) Jack Carlson Brig Gen W. R. Hedrick, Jr Weldon E. Gibson SILVER GLADE (C)				
1 45	XVA COMMERCIAL UTILIZATION OF SPACE CH Walter Hausermann CENTURY (C)	XVB MANAGEMENT OF POWER AND ENERGY RE- SOURCES CH L. M. Robertson BALLROOM (B)	XVC SPACE PROGRAM MANAGEMENT AND MISSION PLANNING - I CH John H. Dishar CORONET (B)	XVD COMMERCIAL OR APPLICATIONS - II CH Bertel W. Kleerup EMPIRE (C)	XVE ASTRONAUTICAL EDUCATION AND HISTORY CH James Allen HOLIDAY (C)
	XV F OR IN EDUCATION - III CH Robert M. Oliver BONANZA (C)	XV G OR IN PUBLIC SYSTEMS - I CH Paul Merry GOLD (B)	XV H LUNAR GEOLOGICAL EXPERIMENTS - III CH Gordon Swan BROADWAY ARMS (C)	XV J ASTRONAUT ACTIVITIES AND SPACE TOOLS - III CH Maj. C. E. Whitsett, Jr. STRATTON/TABOR (B)	
3:15	XVIA SPACE FLIGHT SAFETY CH Jerome Lederer CENTURY (C)	XVIB MANAGEMENT OF WASTE AND POLLUTANTS CH Dave Dominick BALLROOM (B)	XVID COMMERCIAL OR APPLICATIONS - III CH R.B. Grant EMPIRE (C)	XVIE MILITARY OR V CH Richard H. Blythe BONANZA (C)	XVIF MAINTAINABILITY AND RELIABILITY - II CH Robert F. Fotogrody HOLIDAY (C)
	XVIG OR IN PUBLIC SYSTEMS - II CH Gerhardt Clementson GOLD (B)	XVIH LUNAR GEOLOGICAL EXPERIMENTS - IV CH E. J. Zeller BROADWAY/ARMS (C)	XVIJ DECISION THEORY APPLICATIONS CH W. W. Whitman STRATTON/TABOR (B)	XVIK SPACE PROGRAM MANAGEMENT AND MISSION PLANNING - II CH John H. Dishar CORONET (B)	

PLANNING CHALLENGES OF THE 70'S IN SPACE AND THE PUBLIC DOMAIN

ORSA / AAS Joint Meeting

DENVER

17-20 June, 1969

PROGRAM

TUESDAY, JUNE 17, 8:30-9:00 AM

Silver Glade (C)*

OPENING SESSION

Call to Order	GEORGE W. MORGENTHAUER
Welcome	GOVERNOR JOHN LOVE (invited)
Keynote —	CAPT. WALTER M. SCHIRRA, USN, Astronaut

TUESDAY, JUNE 17, 9:00-10:15 AM

Century (C)

IA. Future Manned and Automated Earth Orbital Science Missions

Chairman: WILMOT HESS, Director, Science and Application Directorate, MSC, NASA.

Co-Chairman: CARL L. KOBER, Program Scientist, Manned Space Systems, Martin Marietta Corporation, Denver.

IA.1 "Future Manned and Automated Earth Orbital Science Missions", HENRY J. SMITH, Deputy Administrator, Science, NASA.

Discussants: WILMOT HESS, CARL L. KOBER

*(B) = Brown Palace hotel

(C) = Cosmopolitan hotel

9 9545

TUESDAY, JUNE 17, 9:00-10:15 AM

Ballroom (B)

**IB. Management of Social Institutions:
Penal, Welfare, Education, Job Training**

Chairman: DAVID S. STOLLER, Director, Division of Statistical Studies, Office of Education, Washington, DC.

Co-Chairman: HAROLD MORSE, Supervisor, Research and Statistics, Denver Welfare Center.

- IB.1** The Soft Data Problem: A Case Study of Education, *MICHAEL H. HALBERT, Institute for Study of Inquiring Systems, Philadelphia.*
- IB.2** Problems of Managing Criminal Justice, *ROBERT D. TRUJILLO, Department of Probation Services, County Court, Denver.*
- IB.3** Development of a Central Information System within the Context of a Model Cities Program: Opportunities and Obstacles, *FRANCIS G. CARO, Assistant Director for Evaluative Research, University of Colorado.*
- IB.4** Frontiers in the Planning and Management of Mental Institutions, *PAUL R. BINNER, Chief Research Department, Ft. Logan Mental Health Center, Denver.*
- IB.5** An Analytical Model of a Welfare Case Load, *HAROLD A. MORSE, Research and Statistics, Department of Welfare, Denver.*

TUESDAY, JUNE 17, 9:00-10:15 AM

Bonanza (C)

IC. Space Law

Chairman: PAUL B. DEMBLING, General Counsel, NASA.

Co-Chairman: VED P. NANDA, College of Law, University of Denver.

- IC.1** Liability for Space Activities, *VED P. NANDA, College of Law, University of Denver.*
- IC.2** Space Law—Polar Research as a Model for Space Activities, *JOHN C. EVANS, JR., NASA Lewis Research Center.*
- IC.3** Prospects for Space Law, *MAJOR ALAN HERMAN, U.S. Air Force Academy.*
- IC.4** Evolution of Space Treaties, *PAUL B. DEMBLING, General Counsel, NASA.*

TUESDAY, JUNE 17, 9:00-10:15 AM

Empire (C)

ID. Decision Theory

Chairman: WILLIAM JEWELL, Chairman, Dept. of Operations Research and Industrial Engineering, University of California.

Co-Chairman: GEORGE PARKINS, Dept. of Electrical Engineering, University of Denver.

- ID.1** Mathematical Model for Aerospace Maintenance, *C. M. RIEHL, North American Aviation, Inc., Space Division, Downey, Cal.*
- ID.2** A General Description of an Environmental Information Systems Program, *STEVEN H. COHEN, Office of Atmospheric Water Resources, Bureau of Reclamation, Denver.*
WILLIAM A. PETERMAN, Denver Research Institute, University of Denver.
- ID.3** Bayesian Risk Analysis by Decision Networks, *ANDREW VAZSONYI, North American Rockwell Corporation and University of Southern California.*

TUESDAY, JUNE 17, 9:00-10:15 AM

Onyx (B)

IE. Working Group on Extraterrestrial Resources (WGER I)

Opening Remarks: JAMES J. GANGLER, Chairman, WGER, NASA Headquarters.

Subgroup on Facility Design, Construction and Operation

Chairman: RODNEY W. JOHNSON, Chairman, Subgroup on Facility Design, Construction and Operation, NASA Headquarters.

- IE.1** Design for a Semipermanent Lunar Base, *J. L. ADAMS, Stanford University, Palo Alto, California; J.J. BILLINGHAM, NASA Ames Research Center.*
- IE.2** High Power, Long Life Electrical Generating Systems for Lunar Base Missions, *PAUL R. MILLER, NASA Headquarters.*
- IE.3** No-Loss Cryogenic Storage on the Lunar Surface, *J. H. BELL, JR., The Boeing Company, Huntsville.*

TUESDAY, JUNE 17, 9:00-10:15 AM

Broadway Arms (C)

IF. Military OR I: Field Experimentation

Chairman: GEORGE M. GIVIDEN, Applied Technology Laboratory, Litton Defense Sciences Laboratories, Monterey, Calif. 93941

- IF.1** The Role of Operations Research Techniques in Army Field Experimentation, *VICTOR HEISKAL, Manager, Applied Research Section, Litton Scientific Support Laboratory, Fort Ord, California*
- IF.2** BMEWS Operational Capability Testing, *HERMAN RABITCH, The John D. Kettelle Corp., Colorado Springs, Colo.*
- IF.3** Some Methodological Considerations for Conducting Night Field Experiments, *ROGER WINSLOW, Senior Operations Analyst, Litton Scientific Support Laboratory, Fort Ord, Calif.*

TUESDAY, JUNE 17, 9:00-10:15 AM

Holiday (C)

IG. Advances in Stochastic Processes

Chairman: EDWIN L. CROW, Environmental Science Services Administration, Department of Commerce.

Co-Chairman: IRVING WEISS, Department of Mathematics, University of Colorado.

- IG.1** Dynamical Flow Models and Semi-Markov Processes, *DANIEL P. HEYMAN, Bell Telephone Laboratories, Inc.*
- IG.2** Stochastic Inventory Models with State-Dependent Leadtimes, *D. GROSS, C. M. HARRIS and F. A. MIERCORT, The Research Analysis Corporation.*
- IG.3** To be announced

TUESDAY, JUNE 17, 10:15-12:00 AM

Century (C)

IIA. Earth Orbital Resource Missions

Chairman: DOUGLAS CARTER, Mineral and Land Resources Working Group, U.S. Geological Survey.

Co-Chairman: JEROME G. MORSE, Space Sciences Department, Martin Marietta Corporation, Denver.

- IIA.1** Results of Earth Resources Surveys of the Earth and Plans for Future Satellites, WILLIAM A. FISCHER, U.S. Geological Survey.
- IIA.2** Applications of Earth Orbital Remote Sensing to Forest and Range Problems, ROBERT N. COLWELL, University of California.
- IIA.3** Earth Resource Information Systems, J. R. SHAY, Oregon State University.
- IIA.4** Aerospace Applications in Agriculture and Forestry, A. B. PARK, Agricultural Research Service, U.S. Dept. of Agriculture.
- IIA.5** Synoptic Oceanography: Remote Sensing Studies of the Ocean, J. W. SHERMAN, Naval Oceanographic Office, Department of the Navy.

TUESDAY, JUNE 17, 10:15-12:00 AM

Ballroom (B)

IIB. Management of Population

Chairman: LEO SHAPIRO, Leo Shapiro & Associates, Chicago, Ill.

Co-Chairman: MELVIN CAPEHART, King Resources Co., Denver, Colo.

- IIB.1** On-Line Evaluation of Planned Population Programs, EDWARD H. PALMER, Social Planning Associates, Inc.
- IIB.2** The Use of Multi-State Input-Output Analysis in the Analysis of Population Flow Patterns, RUSSELL C. KOZA, University of Colorado.
- IIB.3** A Mathematical Theory for the Exploitation of Biological Population, STUART H. MANN, Purdue University.

TUESDAY, JUNE 17, 10:15-12:00 AM

Stratton/Tabor (B)

IIC. Astrophysics and Interplanetary Experiments

Chairman: ROBERT CHASSON, Dept. of Physics, University of Denver.

Co-Chairman: HOWARD D. GREYBER, Martin Marietta Corp., Denver.

- IIC.1** The Pioneer Spacecraft Program, GLENN A. REIFF, Pioneer Program, NASA.
- IIC.2** Pulsars—Observations and Theory, STEPHEN P. MARAN, Goddard Space Flight Center.
- IIC.3** High Energy Space Astronomy, GEORGE W. CLARK, MIT.
- IIC.4** Solar Activity and Planetary Positions, J. B. BLIZARD, University of Denver.

TUESDAY, JUNE 17, 10:15-12:00 AM

Holiday (C)

IID. Military OR II: Panel**Relationships Between Military Users
and Operations Research Practitioners***Chairman:* HUGH M. COLE, *Research Analysis Corporation.*

Panel Session sponsored by the Military Applications Section of GRSA

Panel Members: JAMES HENRY, *Institute for Defense Analyses.*
 WILBUR PAYNE, *Deputy Under Secretary (Operations Research),*
Department of the Army.
 PAUL PHILLIPS, *B. Gen. (Ret.) USA, Research Analysis Corp.*
 MARVIN SCHORR, *President, Technical Operations, Inc.*

TUESDAY, JUNE 17, 10:15-12:00 AM

Onyx (B)

IIIE. Working Group on Extraterrestrial Resources (WGER II)**Subprogram on Biotechnology and Human Factors***Chairman:* ROBERT O. MATTHERN, *Chairman, Subprogram on Biotechnology and Human Factors, U.S. Army Munitions Command, Dover, New Jersey***IIIE.1** Toxiological Screening of Space Cabin Materials, G. A. KLEINBERG and A. A. THOMAS, *Chemical Hazards Branch, Wright-Patterson AFB.***IIIE.2** Feeding Man in Space, H. A. HOLLENDER, *Food Division, U.S. Army Natick Laboratories.*

TUESDAY, JUNE 17, 10:15-12:00 AM

Empire (C)

IIIF. Search and Surveillance Models*Chairman:* STEPHEN M. POLLOCK, *Department of Operations Analysis, Naval Postgraduate School.**Co-Chairman:* MAJ. ROBERT W. BURTON, *Director of Faculty Research, U.S. Air Force Academy.***IIIF.1** Search Theory in the Presence of False Targets, MARTIN A. SNYDER, *Bryn Mawr College; LAWRENCE D. STONE, Daniel H. Wagner Associates.***IIIF.2** Problems in the Application of Visual Detection Models, C. P. GREENING, *North American Rockwell Corporation.***IIIF.3** Passive Surveillance Model, RICHARD KLINKNER and LLOYD BELL, *Tetra Tech Corp.***IIIF.4** A Problem in Optimal Search and Stop, SHELDON M. ROSS, *University of California.***IIIF.5** A Simple Moving Target Search and the Golden Section, S. M. POLLOCK, *Naval Postgraduate School.*

TUESDAY, JUNE 17, 10:15-12:00 AM

Bonanza (C)

IIG. Linear Programming

Chairman: GEORGE NEMHAUSER, Associate Professor of Operations Research, The Johns Hopkins University.

Co-Chairman: R. CURTIS JOHNSON, Chairman, Dept. of Chemical Engineering, University of Colorado.

IIG.1 Linear Programming, Spanning Trees, and the Traveling-Salesman Problem, MICHAEL HELD, IBM Systems Research Institute; RICHARD M. KARP, University of California.

IIG.2 On Non-Parametric Sensitivity Analysis in Linear Programming, ROBERT N. BRASWELL and FRED MARSDEN ALLEN, University of Florida.

IIG.3 On the Theory and Applications of Interval Linear Programming, A. BEN-ISRAEL, Northwestern University; P. ROBERS, Research Analysis Corporation.

IIG.4 Set Covering with Equality Constraints, R. S. GARFINKEL and G. L. NEMHAUSER, The Johns Hopkins University.

TUESDAY, JUNE 17, 12:00-1:45 PM

Silver Glade (C)

LUNCHEON

M.C.: RAOUL FREEMAN, Space Sciences Section, ORSA, Pres, Systems Appl., Inc.

Speaker: Apollo—A Reality, COL. FRANK BORMAN, Astronaut.

TUESDAY, JUNE 17, 1:45-3:15PM

Century (C)

IIIA. Large Space Stations, Space Logistics, and Rescue (SOLE)

Chairman. LUDIE RICHARDS, Deputy Director of Science & Engineering, MSFC, NASA.

Co-Chairman: COLIN A. HARRISON, Advanced Systems Marketing, Martin Marietta Corporation, Denver.

IIIA.1 Consideration on Approaches to Space Program Planning and Advanced Design, H. S. BECKER, Advanced Systems Office, MSFC, NASA.

IIIA.2 What It Will Take to Sell A Space Station, HON. ROBERT CASEY, Congressman from Texas.

IIIA.3 Role of The Astronaut in Large Multimanned Stations, WALTER CUNNINGHAM, Astronaut, MSC, NASA.

TUESDAY, JUNE 17, 1:45-3:15 PM

Ballroom (B)

IIIB. Management and Expansion of Food and Forest Resources*Chairman: ROBERT C. LIEBENOW, Corn Refiners Association, Washington, D.C.**Co-Chairman: LEE OLSON, The Denver Post.*

- IIIB.1** Computerized Forest Management, *MICHAEL LAZARA, Greenacres, Inc.*
- IIIB.2** Some Myths About World Hunger, and Why They Must be Dispelled, *ROBERT C. LIEBENOW, Corn Refiners Association.*
- IIIB.3** Microbes as a New Source of Food for the Expanding World Population, *D. M. UPDEGRAFF, Denver Research Institute.*
- IIIB.4** Maximum Productivity from Industry-Owned Forest Lands, *JEROME L. CLUTTER and JAMES E. BETHUNE, University of Georgia.*

TUESDAY, JUNE 17, 1:45-3:15 PM

Stratton/Tabor (B)

IIIC. Planetary Sciences and Experiments*Chairman: R. M. GOODY, Harvard University.**Co-Chairman: A. R. BARGER, Martin Marietta Corporation, Denver.*

- IIIC.1** The Atmospheres of Jupiter and the Outer Planets, *S. I. RASOOL, Goddard Institute for Space Studies.*
- IIIC.2** The Atmosphere of Mars and the Mariner Mars '69 UV Experiments, *C. A. BARTH, et al, University of Colorado.*
- IIIC.3** Optical Properties of the Venus Atmosphere, *ROLAND L. HULSTROM, Martin Marietta Corporation, Denver.*
- IIIC.4** Author to be Announced. A Review of the Results from the Russian Space Probes Venera 5 and 6.

TUESDAY, JUNE 17, 1:45-3:15 PM

Bonanza (C)

IIID. Integer Programming and Applications*Chairman: ROBERT S. NOVOSAD, Faculty of Aeronautical Systems, University of West Florida.**Co-Chairman: PETER C. RYAN, Martin Marietta Corporation, Denver.*

- IIID.1** Partitioning Algorithms in Mixed and Pseudo-Mixed Integer Programming, *ARNAUD L. HENRY-LABORDERE, IBM France.*
- IIID.2** An Application of Linear Integer Programming Using Two Simultaneous Objective Functions and Non-Linear Constraints, *EDWARD K. KUTCHMA, University of Colorado.*
- IIID.3** A Network Isolation Algorithm, *MANDELL BELLMORE, The Johns Hopkins University; GERALD B. BENNINGTON and STEPHEN H. LUBORE, Technical Staff, The MITRE Corporation.*
- IIID.4** A Simplexes Decomposition Algorithm for Integer Linear Programming, *HAJIME ETO, Hitachi Central Research Laboratory.*
- IIID.5** An Improved Combinatorial Programming Algorithm for Zero-One Integer Programming, *JOHN F. PIERCE, MIT School of Management; JEFFREY S. LASKY, MIT Dept. of Operations Research.*

TUESDAY, JUNE 17, 1:45-3:15 PM

Onyx (B)

IIIE. Working Group on Extraterrestrial Resources (WGER III) Subgroup on Environment and Resources

Chairman: MAJ. STUART W. JOHNSON, Assoc. Professor, Dept. of Mechanics, Air Force Institute of Technology.

- IIIE.1 Titanoclinohumite: A Possible Significant Mineralogical Site for Water in the Upper Mantle, THOMAS K. McGETCHIN, Air Force Institute of Technology.
- IIIE.2 Methods for Water Determination (In Situ and Orbital) in Lunar Exploration, ISIDORE ADLER, Goddard Space Flight Center.

TUESDAY, JUNE 17, 1:45-3:15 PM

Empire (C)

IIIF. Advances in Computer Sciences

Chairman: HERBERT J. GREENBERG, Chairman Mathematics Dept., University of Denver.

Co-Chairman: WILLIAM S. DORN, Director of Computer Education, University of Denver.

- IIIF.1 A User Oriented Computer Language for Dynamic Programming, JAMES H. NOLEN and W. L. MEIER, JR., Texas A&M Univ.
- IIIF.2 STIL (A Statistical Interpretive Language), CHARLES E. DONAGHEY, University of Houston.
- IIIF.3 Probabilistic Analysis of a Two-Task Multiprogramming Environment, F. D. KNIGHT, R. S. WOOD and J. E. SUICH, Savannah River Laboratory, E. I. duPont de Nemours and Company.
- IIIF.4 Time Shared Linear Programming Calculations, MICHAEL MONTALBANO, Palo Alto Scientific Center, IBM Corp.

TUESDAY, JUNE 17, 1:45-3:15 PM

Coronet (B)

IIIG. Allocation of R & D Resources

Chairman: FRANCIS P. HOEBER, The RAND Corporation.

Co-Chairman: J. J. BARRY, Martin Marietta Corporation, Denver.

- IIIG.1 Technological Forecasting—What Effect Does It Have on Aerospace Planning, PETER H. NEUKIRCH, Martin Marietta Corporation, Denver.
- IIIG.2 Optimality of Full Funding Strategies in R & D Allocation Problems, T. S. CHIDAMBARAM, Communications Satellite Corp., Bethesda, Md.
- IIIG.3 Probabilistic Manpower Planning for Research and Development Organizations, R. E. SHANNON and L. H. JOHNSON, University of Alabama.
- IIIG.4 Is it Possible to Optimize Allocations of Proposal Resources to Research Proposals in a Large Aerospace Company? SADISH K. ANAND, Martin Marietta Corp., Denver.

TUESDAY, JUNE 17, 1:45-3:15 PM

Holiday (C)

IIII. Cost Effectiveness Section Panel: A Critical Review of Methods of Public Choice

Panel Chairman: OLIVER BRYK, *Exotech Inc. (Systems Research Division), Washington, D.C.*

Panel Members: PAMELA KACSER, HEW, Washington, D.C.; FRED MANSBRIDGE, US Senate Staff, Washington, D.C.; KEITH MARVIN, General Accounting Office, Washington, D. C., FRANK TRINKL, Consultant, Washington, D. C., EDWARD WHALEN, Bureau of Budget, Washington, D. C

The theme of the meeting implies a great task; are our methods for defining and choosing ends and means adequate? What is the challenge to the profession in searching for better methods? A panel of experts in the social, economic, and political aspects of criteria for public choice will discuss and critically review existing and developing methods for selecting objectives, alternatives, and criteria. Social Accounting, Cost-Effectiveness Analysis, PPBS, and political ways of distinguishing between means and ends will be among the topics.

TUESDAY, JUNE 17, 3:15-5:00 PM

Century (C)

IVA. Future Ranges, Spaceports, and Command Control Nets

Chairman: LT. COL. DONN F. EISELLE, *NASA Astronaut.*

Co-Chairman: RICHARD F. CARLISLE, *Program Manager, The Bendix Corporation, Denver.*

- IVA.1 Current and Future Range Considerations, MAJ. GEN. DAVID M. JONES, *Commander Air Force Eastern Test Range.*
- IVA.2 Para Wing Space Shuttle, THEODORE W. KANACKE, *Northrop Corporation.*
- IVA.3 Resource Allocation in Spaceflight Command and Control Networks, PHILIP A. BARRETT, *Lockheed Missiles and Space Co.*
- IVA.4 Planning Space Activities in the 1970's, KLAUSE P. HEISS, *Mathematica, OSKAR MORGENSTERN, Princeton University.*

TUESDAY, JUNE 17, 3:15-5:00 PM

Ballroom (B)

IVB. Management and Expansion of Water Resources

Chairman: S. FRED SINGER, *Deputy Assistant Secretary, Department of Interior.*

Co-Chairman: ARNOLD IVAN JOHNSON, *Chief Water Resource Division, Denver Board of Water Commissioners.*

- IVB.1 Management and Expansion of Water Resources, ERNEST L. HENDRICKS, *Water Resource Division, U.S. Geological Survey.*
- IVB.2 Reclamations Water Challenges for the 70's, FLOYD DOMINY, *Commissioner of Bureau of Reclamation.*
- IVB.3 Optimal Estuarine Water Quality Management, SHISHIR K. MUKHERJEE, *Bechtel Corporation, San Francisco.*
- IVB.4 An Algorithm for Irrigation Project Planning, PETER ROGERS and DOUGLAS V. SMITH, *Harvard University.*
- IVB.5 Management of Water Resources, JOHN W. HUNG, *McDonnell Douglas Astronautics, Huntington Beach, Calif.*
- IVB.6 Water Resources Development for Denver Metropolitan Area, R. E. WIEDEMANN, *Chief of Water Resources, Denver Board of Water Commissioners.*

TUESDAY, JUNE 17, 3:15-5:00 PM

Stratton/Tabor (B)

IVC. Atmospheric and Meteorological Science—I

Chairman: WILLIAM W. KELLOGG, *Director, Laboratory of Atmospheric Science, National Center for Atmospheric Research.*

Co-Chairman: JEROLD M. BIDWELL, *Atmospheric Science, Space Sciences Dept., Martin Marietta Corporation, Denver.*

- IVC.1 The Global Atmospheric Research Program, DOUGLAS K. LILLY, *National Center for Atmospheric Research, Boulder.*
- IVC.2 Buoys in the Sky and Ocean, JOHN E. MASTERSON, *National Center for Atmospheric Research, Boulder.*
- IVC.3 Air, Weather, Climate and Man, JOHN L. BUCKLEY, *Technical Assistant, Office of Science and Technology Executive Office of the President, Washington, D.C.*
- IVC.4 Weather Modifications in the 1970's, ARCHIE M. KAHAN, *Chief, Office of Atmospheric Water Resources, Bureau of Reclamation, Denver.*

TUESDAY, JUNE 17, 3:15-5:00 PM

Coronet (B)

IVD. Financial Modeling

Chairman: MICHAEL SHEGDA, *Principal, Director of Research & Development, Lybrand, Ross Bros., and Montgomery, New York.*

Co-Chairman: H. R. TILLQUIST, *Manager-Management Sciences, Mountain States Telephone Company, Denver.*

- IVD.1 Modeling in Banking, LEROY W. BELHORN, *City National Bank, Columbus, Ohio.*
- IVD.2 Corporate Financial Modeling—The State-of-the-Art, GEORGE W. GERSHEFSKI, *Sun Oil Co., Phila.*
- IVD.3 Financial (Time Sharing) Modeling at General Electric, ROBERT NEWMAN, *General Electric Co., New York.*
- IVD.4 How to Use Security Analysis to Improve Portfolio Selection, JACK L. TREYNOR, *Merrill, Lynch, Pierce, Fenner, and Smith, New York, and FISCHER BLACK, Arthur D. Little, Inc., Cambridge, Mass.*

TUESDAY, JUNE 17, 3:15-5:00 PM

Onyx (B)

IVE. Working Group on Extraterrestrial Resources (WGER IV)
Subgroup on Environment and Resources

Chairman: MAJ. STUART W. JOHNSON, *Associate Professor, Department of Mechanics, Air Force Institute of Technology.*

- IVE.1 Electromagnetic Detection of Lunar Subsurface Water, S. H. WARD, *Professor of Geophysical Engineering; G. R. JIRACEK, University of California; W. L. LINLOR, Space Sciences Division, Ames Research Center, NASA.*
- IVE.2 Lunar Water Exploration in the Marius Hills Region of the Moon, J. CHOATE, *Air Force Institute of Technology; D. MOSBRUGER, Air Force Institute of Technology; M. KEMP, Air Force Institute of Technology; STUART W. JOHNSON, Dept. of Mechanics, Air Force Institute of Technology; THOMAS K. McGETCHIN, Geophysics, Air Force Institute of Technology.*

TUESDAY, JUNE 17, 3:15-5:00 PM

Bonanza (C)

IVF. Nonlinear, Parametric and Stochastic Programming

Chairman: DOUGLAS T. WILDE, Department of Chemical Engineering, Stanford University.

Co-Chairman: JAMES A. LaVITA, Assistant Professor, Department of Mathematics, University of Denver.

IVF.1 Duality Relations, Certainty Equivalents and Bounds for Convex Stochastic Programs with Simple Recourse, W. T. ZIEMBA, The University of British Columbia.

IVF.2 Parameterization of an Activity Vector in Linear Programming, CHAIHO FIM, University of Santa Clara, Calif.

IVF.3 A Solution to the Uncapacitated Facilities Location Problem, P. S. DAVIS and T. L. RAY, Union Carbide Corp., New York, N.Y.

TUESDAY, JUNE 17, 3:15-5:00 PM

Holiday (C)

IVG. Monte Carlo and Simulation

Chairman: IRWIN W. KABAK, Assoc. Prof. of Operations Analysis, New York University.

Co-Chairman: MELVIN R. SMITH, Scientific Computer Operations, Martin Marietta Corporation, Denver

IVG.1 A Performer-Oriented Approach to Systems Quality, RONALD LESSING, Operations Research Staff, H.E.W.

IVG.2 Choice of an Efficient Random Number Generator, SALLY ANDERSON, Technical Staff, RAND Corporation.

IVG.3 An Alternative to Pseudo-Random Number Generators, HERBERT BIXHORN, Technical Staff, BELLCOMM, Inc.

IVG.4 Estimating Sample Size in Simulation Experiments, GEORGE S. FISHMAN, Technical Staff, RAND Corporation.

TUESDAY, JUNE 17, 3:15-5:00 PM

Broadway Arms (C)

IVH. OR Marketing Applications

Chairman: STANLEY I. BUCHIN, Associate Professor of Business Administration, Harvard University.

Co-Chairman: CHARLES HINKLE, Professor of Business Administration, University of Colorado.

IVH.1 Portfolio Analysis in New Product Screening and Development, PAUL F. HASE, The Pillsbury Company.

IVH.2 Practical Applications of Market Planning Models, SHERMAN UCHILL, Multi-Access Computing Corp., Waltham, Mass.

IVH.3 Operations Research Marketing Applications, HERBERT A. GOLDSTEIN, Lybrand, Ross Bros., and Montgomery, New York.

Annual ORSA Business Meeting

Tuesday, June 17, 5:30-6:00 PM

Broadway Arms (C)

Annual AAS Business Meeting

Tuesday, June 17, 5:00-5:30 PM

Empire (C)

Space Movies

Tuesday, June 17, 5:00-6:00 PM

Century (C)

AAS Honors Night Banquet**TUESDAY, JUNE 17**

Silver Glade (C)

6:30 - Cash Bar

7:30 - Dinner

8:45 - Awards and Dinner

M.C. **GEORGE W. MORGENTHALER**, General Program Chairman.*Speaker:* To Be Announced.**WEDNESDAY, JUNE 18, 8:30-10:15 AM**

Century (C)

**VA. Space Ecological Technology and Human Factors
(AIBS)***Chairman:* **EDWARD L. HAYS**, Crew Systems Deputy Chief, MSC, NASA.*Co-Chairman:* **GEORGE RODNEY**, Martin Marietta Corp., Denver.**VA.1** Habitability of Manned Spacecraft, **C. C. JOHNSON**, Spacecraft Design Office, MSC, NASA.**VA.2** Prominence of Space Suits and Life Support Systems in Space, **LARRY E. BELL**, Crew Systems Division, MSC, NASA.**VA.3** Recent Advances in Life Support System Concepts, **JACOB SHAPIRO**, Biotechnology Division, NASA, AMES.

WEDNESDAY, JUNE 18, 8:30-10:15 AM

Holiday (C)

VB. Network Flow Theory*Chairman: D. HAZONY, Case-Western Reserve Univ.**Co-Chairman: ISAAC M. HOROWITZ, Department of Electrical Engineering, University of Colorado.*

- VB.1** Irreversible Operations—A Network Analysis, *J. P. SAKSENA and SANTOSH KUMAR, Research & Development Organisation, New Delhi-12 India.*
- VB.2** An Algorithm for Universal Maximal Dynamic Flows in a Network, *W. L. WILKINSON, The George Washington University.*
- VB.3** Linear Integrated Circuit Design Using State-Space Concepts, *R. W. NEWCOMB and P. DEWILDE, Stanford University.*
- VB.4** Linear Graphs as System Models, *S. D. BEDROSIAN, University of Pennsylvania, Phila., Pa.*
- VB.5** Analysis and Comparison of Various Lower Bounds on Schedule Times For the Solution of the Flow Shop Problem, *SAID ASHOUR and M. N. QURAIISHI, Kansas State U.*

WEDNESDAY, JUNE 18, 8:30-10:15 AM

Bonanza (C)

VC. Spacecraft Materials, Structures, and Mechanisms*Chairman: R. R. HELDENFELS, Langley Research Center, NASA.**Co-Chairman: ARTHUR FELDMAN, Martin Marietta Corp., Denver.*

- VC.1** The LOFT Structure, *JOHN M. HEDGEPEETH, Astro Research Corporation.*
- VC.2** Structural Design and Development of a Tactical Communications Satellite, *PAUL W. BERNSTEIN, Hughes Aircraft Company.*
- VC.3** The Application of Flowgraphs to Elastomechanical Systems, *TORLEIV ENGER and CHUAN C. FENG, University of Colorado.*
- VC.4** Large Space Erectable Structures, *DESMOND H. VAUGHAN, General Dynamics, Convair Division.*
- VC.5** Reusable Lifting Center—Body Launch Vehicle Concept for Pressure Fed Engines, *HANS F. WUENSCHER, MSFC, NASA.*

WEDNESDAY, JUNE 18, 8:30-10:15 AM

Broadway Arms (C)

VD. Dynamic Programming*Chairman: RICHARD BELLMAN, University of Southern California.**Co-Chairman: PERRI STINSON, University of Denver.*

- VD.1** Dynamic Programming and Chemical Engineering, *DOUGLAS WILDE, Stanford University.*
- VD.2** Dynamic Programming Optimization of Water Resources, *W. L. MEIER, JR., Texas A&M College.*
- VD.3** A Dynamic Programming Model for Optimal Gift Allocation in Estate Planning, *HERBERT STONE, California State College at Long Beach.*

WEDNESDAY, JUNE 18, 8:30-10:15 AM

Onyx (B)

**VE. Working Group on Extraterrestrial Resources (WGER V)
Subgroup on Mining and Processing**

Chairman: THOMAS C. ATCHISON, U.S. Bureau of Mines.

- VE.1 Problems of Friction and Adhesion in a Lunar Environment, Panel Discussion by P. B. BLUM, Norton Company; S. A. FIELDS, MSFC, NASA; W. W. ROEPKE, U.S. Bureau of Mines, Minneapolis, Minn.; J. A. RYAN, McDonnell Douglas Co., Santa Monica.
- VE.2 Mining Water and Oxygen on the Moon, ROBERT M. COX, JR., Colo. School of Mines; CARL B. HAYWARD, North American Rockwell; RAYMOND Q. SHOTTS, University of Alabama.

WEDNESDAY, JUNE 18, 8:30-10:15 AM

Empire (C)

**VF. Health Section I:
Technology Applications to Health Systems**

Chairman: GEORGE L. BERGST, Manager, Government Information Systems, Lockheed Missiles and Space Company.

Co-Chairman: ARVID B. BREKKE, Division of Health Administration, University of Colorado.

- VF.1 Modeling the Community Health Service System, ARNOLD H. PACKER, Research Triangle Institute.
- VF.2 The Maternal and Infant Care Simulation Model, FRED KENNEDY, Research Triangle Institute.
- VF.3 A Generalized Model for Planning Shared Health Services, JOHN R. FREEMAN, and MIGUEL F. ZALDIVAR, University of Florida.
- VF.4 An Application of Operations Research Techniques in the Social Security Disability Insurance Program, FRANCIS C. J. ICHNIOWSKI, U.S. Public Health Service; G. THEODORE SAFFRAN, Social Security Administration.

WEDNESDAY, JUNE 18, 8:30-10:15 AM

Ballroom (B)

VG. Costing Techniques and Models

Chairman: HAROLD HORNBY, Mission Analysis Division, NASA Office of Advanced Research & Technology.

Co-Chairman: D. J. NEALE, Martin Marietta Corp., Denver.

- VG.1 The Quantity Versus The Quality of The Data Used in The Derivation of A Cost Estimating Relationship, MORRIS J. ZUSMAN, Institute for Defense Analysis.
- VG.2 Automation of Launch Vehicle Adaptive Costs in Support of Long Range Space Planning, ROBERT E. DROWNS, General Dynamics/Convair.
- VG.3 An Extension of the Theory of Learning Curves, DONALD T. BARSKY, Temple University.
- VG.4 Macrobehavior of RDTE Estimates and Costs, HORACE SCHOW, II, and W. J. TROPF, Systems and Cost Analysis Division, Headquarters, U.S. Army Materiel Command.

WEDNESDAY, June 18, 8:30-10:15 AM

Stratton/Tabor (B)

VH. Logistics Planning Techniques—I

Chairman: JOHN C. GOODRUM, Director, Advanced Program Support Office, MSFC, NASA.

Co-Chairman: JOHN F. DWYER, Martin Marietta Corporation, Denver.

- VH.1** Logistics Aspects of Urban Planning, *JAMES L. CARPENTER, JR., and CHARLES J. INSLEY, JR., Martin Marietta Corp.*
- VH.2** An Efficient Algorithm for Optimizing the Geographic Structure of a Warehouse System, *MELVIN BLITZ, NICODEMO A. CICCIA and GEORGE E. O'ROURKE, Sylvania Electronic Systems.*
- VH.3** An Experiment in the Application of Systems Analysis to Innovational Program Planning in Education, *MARTIN HERSHKOWITZ and SEYMOUR I. FINKEL, Vitro Laboratories.*
- VH.4** Systems and Cost Effectiveness Analysis of the Logistics/Resupply of Manned Space Station, *DANN MANN, and PAUL McKOWEN, Operations Analysis, Martin Marietta Corporation, Denver.*

WEDNESDAY, JUNE 18, 8:30-10:15 AM

Corone: (B)

VJ. Spacecraft Design: Thermal Systems—I

Chairman: MAXIME A. FAGET, Director of Engineering and Development, Manned Spacecraft Center, NASA.

Co-Chairman: ERNEST A. SCHUMACHER, Martin Marietta Corporation, Denver.

- VJ.1** General Guidelines for Thermal Design and Analysis of Orbiting Telescopes, *M. COYLE, Goddard Space Flight Center, NASA; DAVID ALMGREN and DANIEL NATHANSON, Arthur D. Little, Inc., Cambridge, Mass.*
- VJ.2** Thermal Control of the Apollo Telescope Mount, *GEORGE D. HOPSON, MSFC, NASA.*
- VJ.3** Thermal Design for the OSO-F University of Minnesota Experiment, *RICHARD R. ANDERSON, Ball Brothers Research Corporation, Boulder.*
- VJ.4** Thermal Control of Four Apollo Telescope Mount Instruments, *D. E. REGENBRECHT, Ball Brothers Research Corp., Boulder.*

WEDNESDAY, JUNE 18, 8:30-11:00 AM

Martin Marietta Corp.

VK. Future Entry Systems Technology
(Classified Session)

Session VK will be a classified session to be held in the Presentation Room at Martin Marietta Corporation plant at Waterton, Colorado, Wednesday, June 18. All those wishing to attend must file Category IV security clearance with Visitor Control, Martin Marietta Corporation, Box 179, Denver, Colorado 80201, by June 10, 1969. The meeting will be restricted to U.S. citizens and immigrant aliens possessing proper security clearance at Confidential level¹

Chairman: ALFRED C. DRAPER, Assistant Research and Technology, Flight Dynamics Lab, Wright Field.

Co-Chairman: JAMES A. STERHARDT, JR., Martin Marietta Corporation.

- VK.1 Reusable Space Transportation Systems 1970/1980 - An Evolutionary View, *F. RAYMES and J. I. DODDS, Space Division North American Rockwell Corp.*
- VK.2 Future Space Transportation Systems, *R. M. DAVIS, Martin Marietta Corporation, Denver.*
- VK.3 Low-Cost Round Trip Space Transportation Evolution, *RICHARD A. NAU, General Dynamics Convair Division.*
- VK.4 Configuring the Stage-and-Half Space Truck, *JOHN T. LLOYD, Lockheed Missiles and Space Company.*
- VK.5 Low Cost Orbital Transportation—A National Objective, *R. G. QUEST and G. M. FULLER, McDonnell Douglas Astronautics Co.*

WEDNESDAY, JUNE 18, 10:15-12:00 AM

Century (C)

VIA. Motivation and Technology
for Future Manned Planetary Missions

Chairman: ALFRED EGGERS, JR., Assistant Administrator for Policy, NASA, Washington.

Co-Chairman: LIONEL V. BALDWIN, Dean, College of Engineering, Colorado State University.

- VIA.1 Motivation for Future Manned Planetary Missions, *S. FRED SINGER, Deputy Assistant Secretary, Department of the Interior, Washington, D. C.*
- VIA.2 Technology, *JOHN SLOOP, NASA, Washington, D.C.*
- VIA.3 Missions, *E. Z. GRAY, Grumman Aircraft Eng. Corp., Bethpage, L.I. New York.*

WEDNESDAY, JUNE 18, 10:15-12:00 AM

Ballroom (B)

VIB. Management of Recreational, Wildlife, and Cultural Resources

Chairman: GEORGE PRICE, *Director of Parks and Recreation, Arvada, Colorado.*

Co-Chairman: MAURICE D. ARNOLD, *Regional Director, Bureau of Outdoor Recreation, Colorado.*

VIB.1 Wildlife Resources Management and the Human Population, HARRY R. WOODWARD, *Director of Colorado Division of Game, Fish and Parks.*

VIB.2 Recreation in the Year 2,000, MAURICE D. ARNOLD, *Regional Director, Bureau of Outdoor Recreation, State of Colorado.*

VIB.3 To be announced.

WEDNESDAY, JUNE 18, 10:15-12:00 AM

Coronet (B)

VIC. Spacecraft Design: Thermal Systems—II

Chairman: MAXIME A. FAGET, *Director of Engineering and Development, MSC, NASA.*

Co-Chairman: ERNEST A. SCHUMACHER, *Martin Marietta Corp., Denver.*

VIC.1 Flight Observation and Prediction of the Performance of Satellite Thermal Control Surfaces, ROGER K. WEDEL, *Lockheed Missiles and Space Company; MANUEL L. MORRIS, Lockheed California Company.*

VIC.2 A New Concept in Cryogenic Insulation for Spacecraft Propulsion Systems, PAUL STEPHENS, *Convair Division of General Dynamics.*

VIC.3 A Laboratory Method for the Determination of Effective Emittance of Spacecraft Thermal Control Louvers, ANGELO J. BOSCIA, *Fairchild Hiller Corp.*

WEDNESDAY, JUNE 18, 10:15-12:00 AM

Bonanza (C)

VID. Cybernetics in Education

Chairman: JERE W. CLARK, *Director, Center for Interdisciplinary Activity, Southern Connecticut State College.*

Co-Chairman: MAYNARD L. MOE, *Department of Electrical Engineering, University of Denver.*

VID.1 Cybernetics Viewed as a Meta-Language for Unifying Science and Science Education, GEORGE J. KLIR, *Farleigh Dickinson University, N.J.*

VID.2 Systems Analysis as Applied to Educational Technology, ROBERT E. De KIEFFER, *University of Colorado.*

VID.3 Systems Approach to the Utilization of Educational Resources, BELA H. BANATHY, *Defense Language Institute, Monterey, California.*

WEDNESDAY, JUNE 18, 10:15-12:00 AM

Onyx (B)

**VIE. Working Group on Extraterrestrial Resources
(WGER VI) Subgroup on Mining and Processing**

Chairman: THOMAS C. ATCHISON, U.S. Bureau of Mines.

VIE.1 Electrowinning Oxygen from Silicate Rocks, D. G. KESTERKE, U.S. Bureau of Mines.

WEDNESDAY, JUNE 18, 10:15-12:00 AM

Empire (C)

VIF. Health Section—II

Chairman: GEORGE L. BERGST, Manager, Government Information Systems, Lockheed Missiles and Space Company.

Co-Chairman: ARVID B. BREKKE, Division of Health Administration, University of Colorado.

VIF.1 Systems Analysis in Hospital Extended Care Planning, MICHAEL E. COHEN, General Electric Company.

VIF.2 Medical Information Systems, BRADNER L. HISEY, M.D., Lockheed Missiles and Space Company.

VIF.3 The Delivery of Health Care: A Network Flow Problem, ROBERT H. HINKLE, U.S. Naval Weapons Laboratory; ANTHONY M. JEZIOR, School of Industrial Engineering, Georgia Institute of Technology.

WEDNESDAY, JUNE 18, 10:15-12:00 AM

Broadway Arms (C)

**VIG. Optimum Allocation Models
and Case Studies**

Chairman: RICHARD E. BECKWITH, Associate Dean and Professor of Quantitative Methods, Georgia State College.

Co-Chairman: AARON N. SILVER, Systems Analysis, The Martin Marietta Corporation, Denver.

VIG.1 Optimization Techniques and the Assignment of Computer System Components, G. R. SHERMAN, University of Tennessee.

VIG.2 Branch and Bound Methods for Optimizing, C. M. SHETTY, Georgia Inst. of Technology; T. D. CASH, JR., Burlington Management Services Co., Greensboro, N.C.

VIG.3 On Modeling The Resource Allocation and Control Problem, ROBERT N. BRASWELL, University of Florida, Gainesville, Florida.

VIG.4 Optimal Allocation of Missiles Against Area and Point Defenses, FREDERICK A. MIERCORT and RICHARD M. SOLAND, Research Analysis Corporation, McLean, Va.

VIG.5 Determination of the Optimal Number of Units, Operators and Repairmen, BARRY BOECKER, General Dynamics, Forth Worth Division; WILLIAM G. LESSO, Operations Research Group, University of Texas.

VIG.6 "PACE," An Adaptive Real Time Allocation System, WILLIAM H. EVERS and SUNDER S. THAKUR, IBM.

VIG.7 Allocation of Investigative Effort in Multi-Project Decision Problems, Y. S. CHANG, Boston University.

WEDNESDAY, JUNE 18, 10:15-12:00 AM

Stratton/Tabor (B)

VIH. Logistics Planning Techniques--II

Chairman: JOHN C. GOODRUM, Director, Advanced Program Support Office, MSFC, NASA.

Co-Chairman: CHARLES J. LEPORE, King Resources Co.

- VIH.1 In-Flight Maintenance of Space Station and Spacecraft, D. A. BARNES, McDonnell Douglas Astronautics.
- VIH.2 A New Approach to Logistics Management, CLIFFORD J. HALL, AAP, NASA and HILAND GARDNER, General Electric Co.
- VIH.3 Logistics Planning Techniques--A Macro-Systems Approach, JOHN DESSAUER, Xerox Corporation.

WEDNESDAY, JUNE 18, 10:15-12:00 AM

Holiday (C)

VIJ. Report of ORSA Long Range Planning Committee

Chairman: THOMAS E. OBERBECK, Office of Research Analyses, USAF Office of Aerospace Research.

Co-Chairman: R. C. TEGTMEYER, Martin Marietta Corporation, Denver.

At this session the report of the Committee on Long Range Planning will be considered in a round table discussion.

The reaction of the ORSA membership attending this session, along with the recommendations of the council, will comprise inputs to the planning of the Committee for the year 1969-1970.

WEDNESDAY, JUNE 18, Luncheon 12:00-2:30 PM

Silver Glade (C)

- MC:* BRYGHT G. GODBOLD, Exec. Dir., Goals for Dallas
- Speaker:* "The World Game" R. BUCKMINSTER FULLER
- Panel:* CHARLES HAAR, Former Asst. Secy. for Metropolitan Div., HUD
WILLIAM LEAR, Pres., William Lear Enterprises
JONAS E. SALK, M.D., Dir., Salk Inst. for Biological Research
WILLIAM WOLF, Pres., Wolf Research and Development Corp.

WEDNESDAY, JUNE 18, 2:30-4:00 PM

Century (C)

VIIA. Future Lunar Missions

Chairman: CAPTAIN LEE SCHERER/MAL, NASA.

Co-Chairman: ROBERT J. MOLLOY, AAP/MSD Program Director, Martin Marietta Corporation, Denver.

- VIIA.1 Lunar Surface Exploration, O. LYLE TIFFANY, Bendix Aerospace Systems Ann Arbor, Mich.
- VIIA.2 Extraterrestrial Construction, BRUCE HALL, Office of the Chief of Engineers; HARRY N. LOWE, Chief of Extraterrestrial Research Agency.
- VIIA.3 The Challenge of Lunar Exploration, DONALD U. WISE, Apollo Lunar Explorations Operations NASA.
- VIIA.4 Lunar Orbital Exploration, CARL L. KOBER, Martin Marietta Corporation, Denver

WEDNESDAY, JUNE 18, 2:30-4:00 PM

Ballroom (B)

VIIB. Management of Mineral Resources

Chairman: WILLIAM A. VOGELY, Assistant Director for Mineral Resources, United States Bureau of Mines, Washington, D.C.

Co-Chairman: ROBERT RICE, Marathon Oil Company, Denver.

- VIIB.1 Management of Fuel Resources, *RUSSELL J. CAMERON, Cameron and Jones, Inc., Denver.*
- VIIB.2 Management of Non-Fuel Resources, *ALVIN KAUFMAN, Bureau of Land Development.*
- VIIB.3 Planning to Meet the Needs for Mineral Resources, *CHARLES MOTTLEY, Pennsylvania State University.*
- VIIB.4 Planning for Construction Minerals in the Urban Environment, *JAMES R. DUNN and WILLIAM A. WALLACE, Rensselaer Polytechnic Institute.*

WEDNESDAY, JUNE 18, 2:30-4:00 PM

Stratton/Tabor (B)

VIIC. Military OR—III

Chairman: ROBERT A. GESSERT, Research Analysis Corporation.

- VIIC.1 To Be Announced.
- VIIC.2 Minimization of Training Cost and Quantity of Multiskilled Personnel when Requirements are Uncertain, *KENNETH W. HAYNAM, Department of the Army.*
- VIIC.3 On the Adjustment of Indirect Fires by Use of Quasilinearization, *W. D. O'NEIL and J. R. HOLDSWORTH, Litton Industries.*
- VIIC.4 Cost Effective Army Material Testing, *GLEN BENZ, Genge Industries, Inc.*

WEDNESDAY, JUNE 18, 2:30-4:00 PM

Empire (C)

VIID. Space Experiments and Sensors—I

Chairman: GENE MANELLA, NASA, Electronics Research Center.

Co-Chairman: THOMAS R. HEATON, Martin Marietta Corporation, Denver.

- VIID.1 A Review of the Apollo Applications Program Orbital Workshop Experiments, *JACK H. WAITE and ALEX L. MADYDA, MSFC, NASA.*
- VIID.2 A Review of the Apollo Applications Program ATM Experiments, *ARTHUR F. WHITE, JR., MSFC, NASA.*
- VIID.3 A Review of the NASA Astronomy Program, *JESSE L. MITCHELL and MARCEL J. AUEREMANNE, Physics and Astronomy Programs, OSSA, NASA.*
- VIID.4 Space Systems Possibilities for Global Atmospheric Research Programs, *MORRIS TEPPER, NASA-Headquarters and STANLEY RUTTENBERG, NCAR, Boulder.*
- VIID.5 Agricultural Resources Information System—The Users Point of View, *HAROLD G. LORSCH, General Electric Co., Phila.*
- VIID.6 A Concept for an Advanced Space-Based Astronomical Observatory, *JEAN R. OLIVIER and MAX E. NEIN, NASA MSFC, FRED J. STEPUTIS, PETER S. REX, and WILLIAM P. PRATT, Martin Marietta Corp., Denver.*

WEDNESDAY, JUNE 18, 2:30-4:00 PM

Bonanza (C)

VIII. Operations Research in Medical Systems Planning*Chairman: WILLIAM HENDEE, Department of Radiology, University of Colorado.**Co-Chairman: JERRY GIEBINK, Denver Health Research Foundation.*

- VIII.1** Linear Programming in Occupational Medicine, *JAMSHED MODI, Research Triangle Institute, Durham, N.C.*
- VIII.2** A Heuristic Distribution and Allocation Model for Whole Blood, *C. CARL PEGELS and ANDREW JELMERT, State University of New York at Buffalo.*
- VIII.3** Cost-Effectiveness Analysis of Artificial Kidney Systems, *JAMSHED MODI, Research Triangle Institute, Durham, N.C.*
- VIII.4** Optimal Planning of an Emergency Ambulance Service, *COLIN E. BELL, University of California; DAVID ALLEN, Dunlap and Associates, Darien, Conn.*

WEDNESDAY, JUNE 18, 2:30-4:00 PM

Holiday (C)

**VIIF. Spacecraft Test:
Developmental and Simulation***Chairman: MELVYN SAVAGE, Test Director - AAP, Headquarters, NASA.**Co-Chairman: HARRY BRUNS, Martin Marietta Corporation.*

- VIIF.1** A Universal Thermal Flux Simulation System, *RAYMOND L. CHUAN and DONALD A. WALLACE, Atlantic Research Corp.*
- VIIF.2** Protection of Spacecraft from Test Equipment Transients during Thermal, *ROBERT W. ELLISON, Martin Marietta Corp., Denver.*
- VIIF.3** Ground Test Program for Assuring Flight-Worthiness of the Apollo Spacecraft, *G. E. GRIFFITH, C. T. MODLIN, JR., P. C. GLYNN, and D. C. WADE, NASA, MSC.*
- VIIF.4** Testing Requirements and Experience for Astronomical Satellites, *FRED W. PAUL, GSFC, NASA.*

WEDNESDAY, JUNE 18, 2:30-4:00 PM

Onyx (B)

VIIG. Automated Diagnostic Testing Techniques I*Chairman: EDWARD SARKISIAN, Electronics Research Center, NASA.**Co-Chairman: WILLIAM A. HEFFNER, Chief, Advanced Digital Applications, Martin Marietta Corporation, Denver.*

- VIIG.1** The Need for Automatic Test Facilities for Large-Scale Arrays, *EDWARD SARKISIAN, Electronics Research Center, NASA.*
- VIIG.2** Transient Response Testing of Lumped Systems, *S. C. GUPTA, Information and Control Sciences Center, SMU.*
- VIIG.3** Topological Applications in Fault Diagnosis of Linear Systems, *S. PARK CHAN, University of Santa Clara.*
- VIIG.4** An Algebraic Theory of the Analysis and Testing of Digital Networks, *A. BROWN, D. D. JOHNSON, and H. YOUNG, IBM.*
- VIIG.5** Combinatorial Analysis for Check-Out Techniques, *EMIL C. NEU, Stevens Institute of Technology.*

WEDNESDAY, JUNE 18, 2:30-4:00 PM

Coronet (B)

VIII. Spacecraft Reliability, Quality Control and Checkout

Chairman: PETER H. FOWLER, Staff Engineer, Components Department, TRW Systems.

Co-Chairman: A. J. MYERS, Quality Control, Martin Marietta Corporation, Denver.

- VIII.1** Long Life Reliability Problems and Solutions for Valves Under Spatial Environments, J.C. DuBUISSON, Martin Marietta Corporation, Denver.
- VIII.2** Machine Reading of X-Ray Film, J. NERI and J. C. PERNICKA, Martin Marietta Corporation, Denver.
- VIII.3** Parts Selection for Long Life Spacecraft, GEORGE E. NEUNER, TRW Systems, Redondo Beach, Calif.

WEDNESDAY, JUNE 18, 2:30-4:00 PM

Broadway Arms (C)

VIJ. Flight Mechanics and Flight Dynamics

Chairman: JOHN STERRETT, Chief Scientist, NORAD, Colorado Springs, Colo.

- VIJ.1** Economical Planetary Transfers in the Real Planetary Cases, J.P. GRAVIER, C. MARCHAL and R. D. CULP, University of Colorado.
- VIJ.2** Optimum Transfer Between Hyperbolic Asymptotes about a Planet of Finite Size, J. M. WALTON, C. MARCHAL and R. D. CULP, University of Colorado.
- VIJ.3** Decision Policies for Midcourse Corrections to the Trajectory of a Space Vehicle, JOHN T. WAGNER, TRW Systems.
- VIJ.4** Non Linear Longitudinal Dynamics of an Orbital Lifting Vehicle, N. X. VINH, University of Michigan; A. DOBRZELECKI, Air Force Weapons Laboratory.
- VIJ.5** Spacetrack Simulation Model, L. L. WEBER, Computer Sciences Corp., Colorado Springs, Colo.

WEDNESDAY, JUNE 18, 4:00-5:45 PM

Century (C)

VIIIA. Use of Extraterrestrial Resources (WGER)

Chairman: JAMES J. GANGLER, Research Division, Office of Advanced Research and Technology, NASA.

Co-Chairman: JAMES GLIOZZI, Head, Planetary Geology Laboratory, Martin Marietta Corporation, Denver.

- VIIIA:1** Lunar Sinuous Rilles, HAROLD MASURSKY, United States Geological Survey.
- VIIIA.2** The Effect of Use of Lunar Resources on Lunar Logistics and Earth-Lunar Transportation, ERNST STEINHOFF, Holloman Air Force Base.
- VIIIA.3** Water Under the Lunar Surface, THOMAS GOLD, Cornell University.

WEDNESDAY, JUNE 18, 4:00-5:45 PM

Ballroom (B)

VIIIB. Management of Land Use, Urban Planning, and Housing

Chairman: FRANK SMITH, *Director, TVA, Knoxville, Tenn.*

Co-Chairman: DeWITT BAULCH, *Department of Health, Education and Welfare, Environmental Control Administration.*

VIIIB.1 To Be Announced.

VIIIB.2 Project CAIC (Cities-Aerospace Industry Coalition), SHIRLEY THOMAS, *City of Los Angeles.*

VIIIB.3 One Answer from the Aerospace Industry on Low Cost Housing, D. H. CHRISTENSEN, *Panel Lock-Housing Division, Lockheed Aircraft.*

VIIIB.4 Climate as a Factor in Community Environmental Management, J. F. CLARKE and DeWITT BAULCH, *Department of HEW, Cincinnati, Ohio.*

VIIIB.5 Dynamic Land Inventory System, JUDITH MOSS, *Lockheed Company.*

WEDNESDAY, JUNE 18, 4:00-5:45 PM

Empire (C)

VIIIC. Space Experiments and Sensors—II

Chairman: GENE MANNELLA, *NASA, Electronics Research Center.*

Co-Chairman: THOMAS R. HEATON, *Martin Marietta Corp., Denver.*

VIIIC.1 A Radiometer for Measuring Solar Flux Variations, ROGER C. LINTON, *MSFC, NASA.*

VIIIC.2 Deployment of a Tethered Orbiting Interferometer, C. J. SWET and J. M. WHISNANT, *John Hopkins University—APL.*

VIIIC.3 A Multi-Function Radar Sensor for Deep Space Probes, WERNER KOPPL, *Martin Marietta Corporation, Denver.*

VIIIC.4 The Role of Imagery in Unmanned Planetary Orbital Exploration, D. A. KLOPP, *IIT Research Institute, Chicago.*

VIIIC.5 Investigation of an Early Flyby Sequence for Imaging of the Planet Mercury, LARRY A. MANNING, *NASA, AMES.*

WEDNESDAY, JUNE 18, 4:00-5:45 PM

Stratton/Tabor (B)

VIIID. Military OR—IV

Chairman: ROBERT A. GESSERT, *Research Analysis Corp.*

VIIID.1 Deterministic Limits of Probabilistic Lanchester Systems, DANIEL O. ETTER, JR., *Systems Evaluation Division, IDA.*

VIIID.2 Optimum Blocking Tactics for Border Security Systems, A. W. DOBIESKI and R. E. WONG, *Systems Group of TRW Inc.*

VIIID.3 Conus Air Defense Engagement Simulation (CADENS), OLEG V. FEDOROFF, HORACE C. LORCK, and ROBERT A. PATCHETT, *Bradcock, Dunn, and McDonald, Inc.*

VIIID.4 An Economic Analysis of Air Force Mission Support Program Alternatives, WILLIAM GRODOWITZ, *Headquarters, USAF.*

WEDNESDAY, JUNE 18, 4:00-5:45 PM

Coronet (B)

VIIIE. Spacecraft Cost Analysis

Chairman: FLOYD ERICKSON, Director, Economic Analysis, Aerospace Corporation.

Co-Chairman: J. W. BARTER, Systems Engineering, Martin Marietta Corporation, Denver.

- VIIIE.1** Techniques for Space System Cost Analysis Based on System Design Characteristics, JOSEPH A. NEISS, Aerospace Corporation.
- VIIIE.2** Launch Vehicle/Mission Assignment Model, C. J. GOLDEN, Lockheed Missiles and Space Co., E. M. Van VLECK, Mission Analysis Division, NASA, Moffett Field, California.
- VIIIE.3** Budget Smoothing Model for Program Planning, ROBERT E. SLYE, Mission Analysis Division, NASA, Moffett Field, Calif.

WEDNESDAY, JUNE 18, 4:00-5:45 PM

Bonanza (C)

VIIIF. New Applications of Operations Research

Chairman: THOMAS H. DUKE, Chief, Systems Division, U.S. Army Strategic Communications Command, (Sentinal Program).

Co-Chairman: DONALD R. MACKEN, Chief, Tropospheric Systems Section, Department of Commerce.

- VIIIF.1** A Systems Analysis Model of Urbanization and Change: An Experiment in Interdisciplinary Education, CARL F. STEINITZ and PETER ROGERS, Harvard University.
- VIIIF.2** A Feedback Control Approach to Electromagnetic Spectrum Planning Using a Shadow Price, M. G. SOVEREIGN, University of Illinois.
- VIIIF.3** Optimal Utilization of Interceptor Sewers in the Minneapolis-St. Paul Sewer System, S. R. ARORA, Minnesota State Planning Agency, University of Minnesota.
- VIIIF.4** Use of Factor Analysis Technique to Predict Results of Changes in a Multi-Office National Social Insurance System, BARBARA HASKINS, Dept. of HEW, Social Security Administration.
- VIIIF.5** Utilization of an Empiric-Programming Model for Investigations of Urban Development Planning Strategies, JOHN W. DICKEY, Virginia Polytechnic Institute; JOHN T. HARRISON, U.S. Army Corps of Engineers.

WEDNESDAY, JUNE 18, 4:00-5:45 PM

Holiday (C)

VIII G. Queueing Theory and Applications

Chairman: IRWIN GREENBERG, Associate Professor, Dept. of Industrial Engineering & Operations Research, New York University.

Co-Chairman: PAUL McKOWEN, Martin Marietta Corporation, Denver.

VIII G.1 Optimal Economic Design of a Queueing System, IRWIN W. KABAK, New York University.

VIII G.2 One-Machine Sequencing to Minimize Total Tardiness, HAMILTON EMMONS, Cornell University.

VIII G.3 An Algorithm for the Design of Markovian Congestion Systems, HILLEL KUMIN, University of Oklahoma.

VIII G.4 On a Class of Queueing Problems and Discrete Transforms, S. SUBBA RAO, College of Business Administration, Rochester, N.Y.; N. J. JAISWAL, Defense Science Laboratory, Delhi 6, India.

WEDNESDAY, JUNE 18, 4:00-5:45 PM

Onyx (B)

VIII H. Automated Diagnostic Testing Techniques—II

Chairman: EDWARD SARKISIAN, Electronic Research Center, NASA.

Co-Chairman: WILLIAM A. HEFFNER, Chief, Advanced Digital Applications, Martin Marietta Corporation, Denver.

VIII H.1 Automatic Test-An Overview and Classification, WILLIAM A. HEFFNER, Martin Marietta Corporation, Denver.

VIII H.2 Fault Diagnosis of Operational Synchronous Digital Systems, MICHAEL J. DEVANEY and GEORGE W. ZOBRIST, University of Missouri, Columbia.

VIII H.3 A Standard Language for Automated Testing of Electronic Components, F. L. BEADLES, Research Triangle Institute.

VIII H.4 Trend Data Analysis in Automatic Testing, D. L. BALDWIN, Martin Marietta Corporation, Denver.

VIII H.5 Computer-Aided Testing of Integrated Circuits, E. C. BERTNOLLI, F. J. KERN and R. C. PEIRSON, University of Missouri, Rolla.

WEDNESDAY, JUNE 18, 4:00-5:45 PM

Broadway Arms (C)

VIIIJ. Atmospheric and Meteorological Sciences II

Chairman: R. J. CHURCHILL, Colorado State University.

- VIIIJ.1 An Improved Model of the Upper Atmosphere (90 to 1000 Km Altitude), DON K. WEIDNER, MSFC, NASA.
- VIIIJ.2 An Evaluation of updated Atmospheric Density Models Based on Satellite Lifetimes, H. W. GATZKE, Lockheed Missiles and Space Co.; D. K. WEIDNER, MSFC, NASA.
- VIIIJ.3 Swept Frequency Microwave Measurements in Simulated Reentry Environments, R. P. DAVIDSON, R. J. CHURCHILL and J. P. RYBAK, Colorado State University.
- VIIIJ.4 Dominant Electron Cooling Processes in the Ionosphere, W. T. ROBERTS, MSFC, NASA.
- VIIIJ.5 Diffusion Treatment of Thermospheric Probe Data Considering Eddy Diffusion and Oxygen Flux Terms, GARY R. SWENSON, MSFC, NASA.

ORSA BANQUET

WEDNESDAY, JUNE 18

Silver Glade (C)

Cash Bar
Dinner

6:30-7:30 PM
7:30

Chairman: THOMAS CAYWOOD (Incoming ORSA President)*Speaker:* JOSEPH H. ENGEL (Outgoing ORSA President)

THURSDAY, JUNE 19, 8:30-10:15 AM

Century (C)

IXA. Automatic Planetary Probes

Chairman: PETER HAURLAN, Jet Propulsion Laboratory.*Co-Chairman:* JORGAN JENSEN, Martin Marietta Corporation, Denver.

- IXA.1 Challenge of Planetary Exploration, PITT G. THOME, Headquarters, NASA.
- IXA.2 Planetary Explorer Program, P. G. MARCOTTE, Goddard Space Flight Center, NASA.
- IXA.3 The 1973 Mariner-Mercury Mission, PHILLIP ECKMAN, Jet Propulsion Laboratory.
- IXA.4 The Viking Project, JAMES S. MARTIN, JR., Langley Research Center, NASA, and A. THOMAS YOUNG, Langley Research Center, NASA.
- IXA.5 The Pioneer Mission to Jupiter, CHARLES F. HALL and HOWARD F. MATTHEWS, Ames Research Center, NASA.
- IXA.6 Reconnaissance Missions to the Outer Planets, J. E. LONG, JPL.

THURSDAY, JUNE 19, 8:30-10:15 AM

Ballroom (B)

IXB. Surface Transportation and Distribution Systems

Chairman: R. B. CURRY, Management Systems Department, Association of American Railroads, Washington, D.C.

Co-Chairman: WILLIAM J. DAY, Computer Sharing Services, Denver and Rio Grande Western Railroad, Denver.

- IXB.1 Optimum Public Policies for Introducing Transportation Innovations, *ERNEST B. COHEN, General Electric Co., Philadelphia.*
- IXB.2 Optimal Container Inventory and Routing, *W. A. HORN, NBS.*
- IXB.3 Design of Inter-City Ground Transportation Systems, *E. S. DIAMANT, J. R. VADEBONCOEUR, TRW Inc.*
- IXB.4 Railroad Network Simulation Models, *J. N. CETINICH, Southern Pacific Company, San Francisco.*

THURSDAY, JUNE 19, 8:30-10:15 AM

Empire (C)

IXC. Propulsion and Attitude Control Systems

Chairman: ROBERT F. ROSE, Manager of Propulsion Division, JPL.

Co-Chairman: GARY SKARTVEDT, Propulsion Section Chief, Martin Marietta Corporation, Denver.

- IXC.1 Monopropellant Propulsion for Missile and Space Vehicles, *VICTOR A. MOSELEY, TRW Systems.*
- IXC.2 SVM-1, 2, and 4 Apogee Motors for Intelsat Communications Satellites, *T. P. BROWNE, Aerojet-General Corp.*
- IXC.3 Liquid Propellant Beryllium Engines for Space Vehicles, *K. J. KEATE, Rocketdyne Corp., Conoga Park, Calif.*
- IXC.4 The Potential of Low Cost Launch Systems Using Hybrid Propulsion, *DOUGLAS ORDAHL, United Technology Corp., Sunnyvale, Calif.*
- IXC.5 Low Cost Solid Propellant Boosters, *R. WASEL, OART, NASA Headquarters.*

THURSDAY, JUNE 19, 8:30-10:15 AM

Bonanza (C)

IXD. Arms Control—I

Chairman: WALTER L. DEEMER, Deputy Assistant Director, Weapons Evaluation and Control Bureau, U.S. Arms Control and Disarmament Agency.

- IXD.1 Arms Control and National Survival Studies, *RICHARD K. LAURINO, Stanford Research Institute.*
- IXD.2 The Arms Burden and Political-Economic Development in Latin America, *THOMAS A. BROWN, Department of State.*

THURSDAY, JUNE 19, 8:30-10:15 AM

Coronet (B)

IXE. Future Space Power

Chairman: WILLIAM H. WOODWARD, Space Power and Electric Propulsion Division, OART NASA Headquarters.

Co-Chairman: JOHN H. MARTIN, Advanced Electronics and Power Systems, Martin Marietta Corporation, Denver.

IXE.1 Space Power Requirements for Future Science and Manned Missions, WILLIAM H. WOODWARD, OART NASA Headquarters.

IXE.2 Solar Cell-Electrochemical Power Supplies—10W to 50 KW, ARVIN H. SMITH, OART NASA Headquarters.

IXE.3 Applications and Development of Space Nuclear Power Systems, JOSEPH D. LaFLEUR, JR., U.S. Atomic Energy Commission.

IXE.4 Nuclear Power for Space Exploration—2W to 350 KW, FRED SCHULMAN, OART NASA Headquarters.

THURSDAY, JUNE 19, 8:30-10:15 AM

Holiday (C)

IXF. PPBS at Federal, State, and Local Levels — I

Chairman: DAVID NOVICK, Cost Analysis Division, Rand Corp.

IXF.1 PPBS In City, State and County, SELMA J. MUSHKIN, The Urban Institute.

IXF.2 The PPBS Experience: Progress, Problems, Directions, FRED S. HOFFMAN, U.S. Bureau of the Budget, Executive Office of the President.

THURSDAY, JUNE 19, 8:30-10:15 AM

Gold (B)

IXG. Computer Graphics — I

Chairman: THURBER J. MOFFETT, Interactive Graphics, TRW Systems Group.

Co-Chairman: JOHN E. CERVI, Management Systems, Operations Analysis, Martin Marietta Corporation, Denver.

IXG.1 Quality Graphics at 6000 Characters Per Second, ROBERT S. COPE, V.P. Autographics, Inc.

IXG.2 Current Advances In Computer Graphics, S. M. MATSA, IBM, New York Scientific Center.

THURSDAY, JUNE 19, 8:30-10:15 AM

Onyx (B)

IXH. Lunar Surface Geology — I

Chairman: HAROLD MASURSKY, Center of Astrogeology, U.S. Geological Survey.

Co-Chairman: J. E. ANDERSON, Department of Geology, University of Kansas.

IXH.1 Observations of Lunar Transient Phenomena (LPT) in the Aristarchus Region, W. S. CAMERON, Goddard Space Flight Center, NASA.

IXH.2 Statistical Geomorphology of the Lunar Surface, L. B. RONCA and R. R. GREEN, Boeing Scientific Research Labs.

IXH.3 Impact Cratering and Shock Metamorphism as Major Lunar Processes, N. M. SHORT, Goddard Space Flight Center, NASA.

THURSDAY, JUNE 19, 8:30-10:15 AM

Stratton/Tabor (B)

IXJ. Transportation Sciences Section — I

Chairman: F. A. P. FRISCH, *Challenger Research, Inc., Rockville, Maryland.*

Co-Chairman: RONALD J. HENSEN, *University of Denver.*

- IXJ.1 Safety Considerations for a High Density Automated Vehicle System, MICHAEL LENARD, *General Electric Co., Erie, Pa.*
- IXJ.2 The Analysis of a T-Type Traffic Intersection Using GERT, G. E. WHITEHOUSE and C. A. ROTH, *Lehigh University.*
- IXJ.3 Propagation of On-Ramp Density Perturbations on Unidirectional Two- and Three-Lane Freeways, L. A. PIPES and P. K. MUNJAL, *System Development Corporation, Santa Monica.*
- IXJ.4 An Experimental Validation of the Boltzmann-Type Statistical Models for Multi-Lane Traffic Flow, P. K. MUNJAL and A. V. GAFARIAN, *System Development Corporation, Santa Monica, and J. PAHL, UCLA.*
- IXJ.5 Asymptotic Properties of Delay-Minimizing Schedules, S. HABER and A. J. GOLDMAN, *National Bureau of Standards.*

THURSDAY, JUNE 19, 10:15-12:00 AM

Century (C)

XA. Unmanned Cometary, Asteroid, and Interplanetary Probes

Chairman: PITT THOME, *Director, Advanced Programs, NASA.*

Co-Chairman: DAVID SONNABEND, *Ball Brothers.*

- XA.1 High Performance Integrated Space System: The Workhorse of Unmanned Space Exploration, M. W. HUNTER and J. H. GUILL, *Lockheed Missile & Space Company.*
- XA.2 Missions to the Comets, DAVID L. ROBERTS and ALLEN FRIEDLANDER, *IIT Research Institute, Chicago.*
- XA.3 Design of an Advanced Meteoroid Probe of the Asteroid Belt, SIDNEY L. RUSSAK, *Martin Marietta Corp., Denver.*
- XA.4 Early Exploration of the Asteroids Region by Solar Powered Electrically Propelled Spacecraft, J. R. WROBEL and D. J. KERRISK, *Jet Propulsion Laboratory.*

THURSDAY, JUNE 19, 10:15-12:00 AM

Ballroom (B)

XB. Air Transportation and Distribution Systems

Chairman: J. C. MAXWELL, *Director of Supersonic Transport Development, Federal Aviation Administration.*

Co-Chairman: TED BRYANT, *Flight Training Center, United Airlines, Denver.*

- XB.1 Supersonic Transport in the Future, J. C. MAXWELL, *Federal Aviation Administration.*
- XB.2 State Department of Transportation, TED BRYANT, *United Airlines.*
- XB.3 VSTOL Aircraft, CLIFTON von KAAN, *Air Transport Association.*
- XB.4 Jumbo Jets, JACK STEINER, *Boeing Company.*
- XB.5 Economic Impact on Domestic Air Traffic: An Econometric Approach, B. R. LIPPKE and J. R. STEWART, *The Boeing Company.*

THURSDAY, JUNE 19, 10:15-12:00 AM

Empire (C)

XC. Advanced Propulsion

Chairman: ADELBERT O. TISCHLER, Director, Chemical Propulsion, Advanced Research and Technical Office, NASA.

Co-Chairman: HEINZ MUELLER, Martin Marietta Corporation, Denver.

- XC.1 Advanced Chemical Propulsion Systems, R. R. ATHERTON, United Aircraft Corporation, West Palm Beach, Fla.
- XC.2 Electric Propulsion Applications, WILLIAM R. MICHELSEN, Colorado State University.
- XC.3 Nuclear Propulsion for Exploration of the Solar System, J. P. LAYTON, Princeton University.

THURSDAY, JUNE 19, 10:15-12:00 AM

Bonanza (C)

XD. Arms Control – II

Chairman: WALTER L. DEEMER, Weapons Evaluation and Control Bureau, U.S. Arms Control and Disarmament Agency.

- XD.1 Strategic Superiority, Deterrence, and Arms Control, JOSEPH I. COFFEY, University of Pittsburgh.
- XD.2 Arms Control and Nuclear Safeguards, FRANK S. HOUCK, U.S. Arms Control and Disarmament Agency.

THURSDAY, JUNE 19, 10:15-12:00 AM

Coronet (B)

XE. Space Telecommunications

Chairman: WM. C. LINDSEY, University of Southern California.

Co-Chairman: R. B. BLIZARD, Martin Marietta Corporation, Denver.

- XE.1 The Promise of UHF Satellite for Mobile, Broadcast, and Austere Services, J. L. HULT, Rand Corporation.
- XE.2 Antenna Systems for Future Communication Satellites, W. H. KUMMER, Hughes Aircraft Company.
- XE.3 An Experimental Direct TV Broadcast from Satellites, SAMUEL W. FORDYCE, NASA Headquarters.
- XE.4 Deployment Latch-up Dynamics of an Erectable Truss Antenna, M. DOWNING and H.A. MITCHELL, General Dynamics, Convair Division, San Diego.

THURSDAY, JUNE 19, 10:15-12:00 AM

Holiday (C)

XF. PPBS at Federal, State, and Local Levels—II

Chairman: DAVID NOVICK, Cost Analysis Division, Rand Corp. (Sponsored by the Cost Effectiveness Section of ORSA).

- XF.1 Program Budgeting in New York City, FRED HAYES, New York City Bureau of the Budget.
- XF.2 Plasticity and Conformity in the Application of System Budgeting by State Governments, ALLEN SCHICK, The Brookings Institution.

THURSDAY, JUNE 19, 10:15-12:00 AM

Gold (B)

XG. Computer Graphics – II

Chairman: THURBER J. MOFFETT, Interactive Graphics, TRW Systems Group.

Co-Chairman: JOHN E. CERVI, Management Systems, Operational Analysis, Martin Marietta Corporation, Denver.

- XG.1 Illinois State University Summer Institute in Computer Graphics, JOE E. TALKINGTON, Illinois State University.
- XG.2 How to Solve Ill-Structured Problems, FRANZ SELIG, Mobile Research and Development Corporation.

THURSDAY, JUNE 19, 10:15-12:00 AM

Onyx (B)

XH. Lunar Surface Geology – II

Chairman: J. E. ANDERSON, Department of Geology, University of Kansas.

Co-Chairman: HAROLD MASURSKY, Center of Astrogeology, U.S. Geological Survey.

- XH.1 Lunar Lava Flows, Mare Ridges and Related Features, R. G. STROM, Lunar and Planetary Laboratory, University of Arizona.
- XH.2 Lunar Volcanism, JACK GREEN, Douglas Advanced Research Laboratories.
- XH.3 Chemical Composition of the Lunar Surface from the Alpha-Scattering Experiments at Three Surveyor Landing Sites, E. J. FRANZGROTE, Jet Propulsion Laboratory; J. H. PATTERSON, Argonne National Laboratory; A. L. TURKEVICH, University of Chicago.

THURSDAY, JUNE 19, 10:15-12:00 AM

Stratton/Tabor (B)

XJ. Modeling of Inventory Systems

Chairman: ALLEN V. BUTTERWORTH, *Research Laboratories, General Motors Corporation.*

Co-Chairman: JAMES D. DONAHUE, *Technodyne Division, Falcon Research and Development Co.*

- XJ.1 Recent Developments in Deterministic Inventory Theory, G. D. EPPEN, *University of Chicago.*
- XJ.2 Recent Developments in Stochastic Inventory Theory, D. IGLEHART, *Stanford University.*
- XJ.3 Min-Max Deterministic Inventory Models, G. WRIGHT and T. IKEDA, *Northwestern University.*
- XJ.4 A Comparison of Economic Lot Size and Minimum Cost Production Methods, D. S. PLYMALE, *Delco Radio Division, GM Corporation.*
- XJ.5 An Empirical Study of Some Multiproduct Inventory Problems, A. C. WHEELER and J. T. WITHERSPOON, *Washington University.*
- XJ.6 Seasonal Demand in Multiple Item Inventories, J. R. GILLESPIE, *Research Laboratories, GM Corporation.*

THURSDAY, JUNE 19, 1:45-3:15 PM

Century (C)

**XIA. Search for Extraterrestrial Life
and Exobiology (AIBS)**

Chairman. RICHARD YOUNG, *Exobiology, NASA Headquarters.*

Co-Chairman: RUSSELL T. JORDAN, *Space Biomedical Research, Martin Marietta Corporation.*

- XIA.1 Detailed Overview of Individual Experiments and the Lander Scientific Program. (Applies to Viking Program), GERALD SOFFEN, *Langley Research Center.*
- XIA.2 Detection and Identification of Organic Compounds on Other Planets, KLAUS BIEMAN, *Department of Chemistry, MIT.*
- XIA.3 Experimental Concepts for Life Detection Methods Applicable to Mars, VANCE OYAMA, *Ames Research Center, NASA.*
- XIA.4 Introductory Overview of the Mars '73 Lander. (Entire scientific payload for Viking Program), DONALD REA, *NASA Headquarters.*

THURSDAY, JUNE 19, 1:45-3:15 PM

Ballroom (B)

XIB. The Coming Information Explosion: Library and Information Management

Chairman: MARVIN W. McFARLAND, *Science and Technology Division, United States Library of Congress.*

Co-Chairman: THOMAS WHITBY, *University of Denver Graduate School.*

- XIB.1 The Coming Information Explosion, *HOWARD J. HILTON, Pennsylvania State University.*
- XIB.2 A Matrix Approach to Management Information System Design, *C. S. HWA, CompuSys., Inc., Albuquerque.*
- XIB.3 Ultrafiche and Its Application to Colleges and Universities, *JAMES P. KOTTENSTETTE, Denver Research Institute.*
- XIB.4 Coming Information Explosion: Information Storage Models, *FERDINAND F. LEIMKUHLER, University of California, Berkley.*

THURSDAY, JUNE 19, 1:45-3:15 PM

Coronet (B)

XIC. Advanced Upper Stages

Chairman: HEINRICK J. WEIGAND, *Scientific Advisor Director of Space, DCS-Research Development, Headquarters, U.S. Air Force.*

Co-Chairman: JAMES W. McCOWN, *Martin Marietta Corporation, Denver.*

- XIC.1 Status of Current Upper Stages, *STANLEY A. GREENE, Titan III Directorate, Aerospace Corp.*
- XIC.2 NASA Space Program Possibilities and Upper Stage Implications, *BERNARD MAGGIN, Office of Program Plans and Analysis, NASA Headquarters.*
- XIC.3 Design Alternatives for Advanced Upper Stages, *JAMES W. McCOWN and GERALD E. MASON, Martin Marietta Corp., Denver.*
- XIC.4 National Space Launch Systems—An Overview, *WILLIAM H. WETMORE, Aerospace Corporation.*

THURSDAY, JUNE 19, 1:45-3:15 PM

Gold (B)

XID. Game Theory and Applications

Chairman: LLOYD SHAPLEY, *Rand Corporation.*

Co-Chairman: PERRI STINSON, *University of Denver.*

- XID.1 Results and Directions in n-Person Cooperative Games, *WILLIAM LUCAS, Rand Corporation.*
- XID.2 An Example in the Theory of Differential Games, *JAMES H. CASE, University of Wisconsin.*
- XID.3 Lagrange Multiplier Solutions to Constrained Matrix Games, *ALLAN PENN, Lambda Corp., Arlington, Va.*
- XID.4 Solving Classes of Infinite Games by Linear Programming, *TIMOTHY W. RUEFLI, University of Texas.*

THURSDAY, JUNE 19, 1:45-3:15 PM

Empire (C)

XIE. Onboard Data Management*Chairman: W. C. BRADFORD, NASA Manned Spacecraft Center.**Co-Chairman: E. C. WOOD, Martin Marietta Corporation.*

- XIE.1** A Systems Approach to Data Management, *JOSEPH C. HELLAND, McDonnell-Douglas Astronautics Company.*
- XIE.2** Onboard Data Management Systems, *JAMES F. HUGHES, NASA Manned Spacecraft Center.*
- XIE.3** Automatic Maintenance Aspects of Data Processing in Unmanned Spacecraft, *ALGIRDAS AVIZIENIS and DAVID A. RENNELS, Jet Propulsion Lab.*
- XIE.4** Science Data Management Automation Systems for Spacecraft, *REID H. CLAUSEN, Martin Marietta Corp., Denver.*

THURSDAY, JUNE 19, 1:45-3:15 PM

Holiday (C)

**XIF. Cost-Effectiveness Section:
Poverty Studies — I***Chairman: JOSEPH A. KERSHAW, Ford Foundation, New York.*

- XIF.1** Application of Cost-Benefit Analysis to Federal Manpower Programs, *LILLIAN REGELSON, OEO, Executive Office of the President.*
- XIF.2** An Experimental Approach to Program Analysis: Step Child in the Social Sciences? *WORTH BATEMAN, Office of Planning and Evaluation, HEW.*
- XIF.3** To be announced.

THURSDAY, JUNE 19, 1:45-3:15 PM

Bonanza (C)

XIG. OR Applications in Economics*Chairman: ERNEST J. MOSBAEK, Economics and Operations, General Electric (TEMPO).**Co-Chairman: CLAUDE McMILLAN, Division of Management Science, University of Colorado.*

- XIG.1** Energy Utilization and Aid Effectiveness in Non-mechanized Agriculture: A Computer Simulation of a Socioeconomic System, *DOUGLAS DAETZ, Sylvania Electronic Systems—Western Division.*
- XIG.2** A Control System Excitation-Response Model for Import-Proportion in a National Economy, *P.S. SATSANGI, S. S. SENGUPTA and J. B. ELLIS, University of Waterloo, Ontario.*
- XIG.3** The Application of Taylor's Theorem in Obtaining the Probability Distribution of Long-Range Profit, *DENNIS E. SMITH, HRB-Singer, Inc., State College, Penn.*
- XIG.4** Significance of Changing Technology and Economics for the Distribution Company of the Future, *R. A. HAMMOND, McKinsey & Company, Inc.*
- XIG.5** A Depreciation Simulation Model, *LUKE J. SPARVERO, Consad Research Corp., Pittsburgh, Pa.*

THURSDAY, JUNE 19, 1:45-3:15 PM

Onyx (B)

XIH. Lunar Surface Environment -- I

Chairman: LUCIANO B. RONÇA, Boeing Scientific Research Laboratories, Seattle, Washington.

Co-Chairman: J. E. ANDERSON, Department of Geology, University of Kansas.

- XIH.1 Mechanical Properties of Lunar Soil, R. F. SCOTT, California Institute of Technology.
- XIH.2 Deposition of Comets and Interplanetary Debris on the Lunar Surface, D. B. BEARD, University of Kansas.
- XIH.3 The Lunar and Cislunar Environment, J. F. KENNEY, Boeing Scientific Research Labs., Seattle, Washington.

THURSDAY, JUNE 19, 1:45-3:15 PM

Stratton/Tabor (B)

XIJ. Transportation Sciences Section II

Chairman: F. A. P. FRISCH, Challenger Research, Inc.

Co-Chairman: RONALD J. HENSEN, University of Denver.

- XIJ.1 Canel Lock Simulation, GEORGE F. WIGGERS, Department of Transportation.
- XIJ.2 The Simulation of Intercity Travel Demands, P. M. PEARSON, University of Waterloo.
- XIJ.3 Temporal Expansion of a Transportation Network, S. C. FREY and G. L. NEMHAUSER, Johns Hopkins University.
- XIJ.4 Economic Analysis of Air Eligibility of Military Overseas Shipments in Peacetime, R. D. GOODFRIEND, Research Analysis Corporation.
- XIJ.5 The Application of OR to Stop Selection and Sequencing for the Aeromedical Evacuation Problem, T. E. KOWALSKY, J. GRIFFIN, and G. M. CUSACK, U.S.A.F.

THURSDAY, JUNE 19, 3:15-5:00 PM

Century (C)

XIIA. Beyond the Solar System

Chairman: KRAFFT EHRICKE, Chief Scientific Advisor Advanced Programs, Space Division, North American Rockwell Corp.

Co-Chairman: HEINZ MUELLER, Martin Marietta Corporation, Denver.

- XIIA.1 Accessible Regions Beyond the Solar System, MAXWELL W. HUNTER, Lockheed Missiles and Space Co.
- XIIA.2 Evolution of Interstellar Operations, KRAFFT EHRICKE, North American Rockwell Corp., Downey, Calif.
- XIIA.3 Interstellar Travel, A Round Trip Propulsion System With Relativistic Velocity Capabilities, PHILIP NOREM, Director of Engineering, Peninsula Research and Development Corp., Fort Erie, Ontario.

THURSDAY, JUNE 19, 3:15-5:00 PM

Ballroom (B)

XIIB. Financing, Marketing and Advertising for Resource Development

- Chairman:* NEWTON ABLAHAT, *Vice President Corporate Planning, Investors Diversified Services, Minneapolis, Minn.*
Co-Chairman: RICHARD HESPOS, *King Resources Company, Denver, Colo.*

- XIIB.1 The Investment in Natural and Human Resources, JOHN M. KING, *King Resources.*
 XIIB.2 Improving the Analysis of Water Resources, IRA A. WATSON, *Division of Economic Planning, Denver Federal Center.*
 XIIB.3 Participating in the Growth of Emerging Economics, HAL S. DYNAN, *Chase-Manhattan Bank.*

THURSDAY, JUNE 19, 3:15-5:00 PM

Coronet (B)

XIIC. Advanced Launch Vehicle and Upper Stage Technology

- Chairman.* HAROLD S. BECKER, *Deputy Director, Advanced Systems Office, NASA.*
Co-Chairman: RICHARD C. LEA, *Program Director, Launch Vehicles Applications, Martin Marietta Corporation.*

- XIIC.1 Reusable Launch Vehicle Concepts, EUGENE LOVE, *Aerophysics Division, NASA, LRC.*
 XIIC.2 Low Cost Boosters, DONALD M. ROSS, *USAF Rocket Propulsion Laboratory.*
 XIIC.3 Simplified Low Cost Expendable Vehicles, DAN DRISCOLL, *MSFC, NASA.*
 XIIC.4 Use of Multiple Outlets for Reducing the Effect of Stratification on Propellant Supply Temperature Variations, R. J. SCHOENHALS and E. R. F. WINTER, *School of Mech. Engineering, Purdue University, and R. N. NELSON, US Navy.*

THURSDAY, JUNE 19, 3:15-5:00 PM

Gold (B)

XIID. Gaming

- Chairman:* CLAYTON J. THOMAS, *Assistant for Research, Operations Analysis, Headquarters, United States Air Force.*
Co-Chairman: PAUL L. GROOVER, *Martin Marietta Corporation.*

- XIID.1 Why People Play Games—Report of a Survey, CLAYTON J. THOMAS and GERALD M. McNICHOLS, *Operations Analysis, Office, Vice Chief of Staff, USAF.*
 XIID.2 Experimental Uses of the Political Military Exercise, JOHN D. STEINBRUNER, *MIT.*
 XIID.3 Trends in Military Gaming, MILTON G. WEINER, *The Rand Corporation.*
 XIID.4 Computer Time Sharing in Business Gaming, F. WARREN McFARLAN, *Harvard University.*
 XIID.5 Some Elementary Bargaining Models, BEN T. RHODES, SR., *University of Houston.*

THURSDAY, JUNE 19, 3:15-6:00 PM

Empire (C)

XIIE. Guidance, Control and Navigation

Chairman: STEVE S. HU, Director of Research Analysis, Northrop Electronics Division.

Co-Chairman: JAMES R. STEPHENS, Martin Marietta Corporation.

Co-Chairman: LT. COL. JOHN WITTRY, Deputy Head for Astronautics, Department of Astronautics and Computer Science, U.S. Air Force Academy.

- XIIE.1** Flight Evaluation Radar-Inertial Systems, RICHARD J. HAYES, NASA Electronics Research Center.
- XIIE.2** Low Cost Inertial Navigation, WILLIAM J. WHITESELL, U.S. Air Force Academy.
- XIIE.3** Guidance Scheme for Low Thrust Parabolic Insertion, ROREN A. SCHULTZ, The Boeing Company; STEVE S. HU, Radio Navigation Systems Lab., Northrop Electronics Div.
- XIIE.4** Simplified Performance Analysis of Space and Missile Guidance, JOHN T. WAGNER, Guidance Software Dept.; DONALD F. McALLISTER, Systems Analysis and Software Dept., TRW Systems.
- XIIE.5** Navigation for Surface and Aerospace Vehicles by a Very Low Frequency Radio Network, H. W. TURNEY, JR., Radio Navigation Systems Lab., Northrop Electronics Div.
- XIIE.6** Contribution of Navigation Analysis of Onboard Systems to Mission Planning in the 70's, JAMES L. KNOEDLER, Systems Evaluation Department, TRW Systems Group.
- XIIE.7** Optimal Attitude Control System for Spinning Aerospace Vehicles, F. S. SOHONI and D. R. GUILD, IBM.

THURSDAY, JUNE 19, 3:15-5:00 PM

Holiday (C)

**XIIF. Cost-Effectiveness Section:
Poverty Studies – II**

Chairman: JOSEPH A. KERSHAW, Ford Foundation, New York.

- XIIF.1** The Status of Methods in Cost-Effectiveness Studies of Social Action Programs, ROBINSON HOLLISTER, Institute for Research on Poverty, University of Wisconsin.

Discussion: ROBERT A. LEVIN, Office of Economic Opportunities.

THURSDAY, JUNE 19, 3:15-5:00 PM

Bonanza (C)

XIIG. Forecasting Technological Change*Chairman: Maj. JOSEPH P. MARTINO, Holloman AFB.**Co-Chairman: REX E. PAULSEN, Martin Marietta Corp., Denver.*

- XIIG.1** Decade Forecasting Methodology Based Upon Information Progression, *J. C. HOAGLAND and G. E. SMITH, McDonnell Douglas Astronautics Company.*
- XIIG.2** Forecasting by Trend Extrapolation, *T. I. MONAHAN, Naval Applied Science Laboratory.*
- XIIG.3** Opinion Technology, *N. C. DALKEY, The Rand Corporation.*
- XIIG.4** A Synthesis Approach to Technological Forecasting, *ROBERT W. PREHODA, Technological Forecasting Associates, Inc., Encino.*

THURSDAY, JUNE 19, 3:15-5:00 PM

Onyx (B)

XIIH. Lunar Surface Environment — II*Chairman: J. E. ANDERSON, Department of Geology, University of Kansas.**Co-Chairman: LUCIANO B. RONCA, Boeing Scientific Research Laboratories.*

- XIIH.1** Chemical Alterations Resulting from Proton Irradiation of the Lunar Surface, *E. J. ZELLER, G. DRESCHOFF, and L. KEVAN, University of Kansas.*
- XIIH.2** Effects of Simulated Solar Wind on Silicate Material Expected to be Present on the Lunar Surface, *J. P. DYBWAD, U.S. Air Force Cambridge Research Lab.*
- XIIH.3** Thermophysics of the Lunar Surface, *J. M. SAARI, Boeing Scientific Research Labs.*

THURSDAY, JUNE 19, 3:15-5:00 PM

Stratton/Tabor (B)

XIIJ. Transportation Sciences Section—III*Chairman: F. A. P. FRISCH, Challenger Research, Inc.**Co-Chairman: RONALD J. HENSEN, University of Denver.*

- XIIJ.1** Cost-Effectiveness Analysis for Evaluating Alternative Emergency Medical Care Recovery Systems, *E. HANITZSCH and W. K. HALL, Highway Safety Research Institute.*
- XIIJ.2** Effectiveness of V-STOL Networks in Metropolitan Areas, *J. F. DUVIVIER, The Boeing Company.*
- XIIJ.3** Energy Budget in Urban Road Transportation, *C. L. COHEN, F. A. P. FRISCH, and J. M. KUCHARSKI, Challenger Research, Inc.*
- XIIJ.4** Search and Choice in Transport Systems Planning, *M. L. MANHEIM, MIT.*

COST EFFECTIVENESS SECTION BUSINESS MEETING

THURSDAY, JUNE 19, 5:00-6:30 PM

Holiday (C)

FRIDAY, JUNE 20, 8:30-10:15 AM

Century (C)

XIIIA. Space Applications:
Weather and Navigation

Chairman: WILLIAM NORDBERG, Assistant Chief, Laboratory for Atmosphere and Biological Sciences, Goddard Space Flight Center.

Co-Chairman: WILLIAM MARLATT, Colorado State University.

XIIIA.1 The Recent Advances in Navigation by Satellite, EUGENE EHRICK, NASA Headquarters.

XIIIA.2 Meteorological Satellites—Beyond the First Nine Years, R. L. HALEY, NASA Headquarters.

XIIIA.3 Advanced Operational Meteorological Satellites, CLIFF SPOHN, National Environment Satellite Center.

FRIDAY, JUNE 20, 8:30-10:15 AM

Ballroom (B)

XIIIB. National Economic Planning

Chairman: HENRI THEIL, Director of Center for Mathematical Studies of Business and Economics, University of Chicago.

Co-Chairman: JOHN Y. KUARK, Associate Professor of Statistics and Economics, University of Denver.

XIIIB.1 A Mean Variance Approach to Optimal Policy Choice Under Uncertainty, CAROL CORRADO, Carnegie-Mellon University.

XIIIB.2 Decentralized Decision-Making for National Development, IRMA ADELMAN and FREDRICK L. GOLLADAY, Northwestern University.

XIIIB.3 Macro Economic Decision Model For National Planning, JOHN Y. KUARK, University of Denver.

FRIDAY, JUNE 20, 8:30-10:15 AM

Stratton/Tabor (B)

XIIIC. Space Biology and Sterilization (AIBS)

Chairman: J. STERN, Consultant.

Co-Chairman: R. T. JORDAN, Martin Marietta Corporation, Denver.

XIIIC.1 Lunar and Planetary Contamination/Prevention and Detection, MARTIN FAVERO, USPHS.

XIIIC.2 Impact of Planetary Quarantine Requirements on the Viking '73 Project, J. MARTIN and LEO DASPIT, Langley Research Center, NASA.

XIIIC.3 Space Biology and Biosatellites, DALE JENKINS, NASA.

XIIIC.4 Epidemiology of Rapid Mass Transit in the 70's, Author to be announced.

XIIIC.5 Potential Effects of Developments in Space Biology and Sterilization Technology on Society in the 70's, RICHARD BOND, University of Minnesota.

FRIDAY, JUNE 20, 8:30-10:15 AM

Empire (C)

XIIID. ORSA Space Science I: Long Duration Spacecraft, Satellites, and Logistics

Chairman: MARTIN R. KINSLER, *North American Rockwell, Inc.*

Co-Chairman: WILLIAM H. CLOHESSY, *Martin Marietta Corp, Denver.*

- XIIID.1 Optimal Resource Allocations for Space Logistics Missions, *J. F. DELFICO, Aerospace Corp.*
- XIIID.2 Methodology for Design of Long Duration Spacecraft, *W. H. ALLEN, NASA OART, Missions Analysis Division, Moffett Field, Cal.*
- XIIID.3 Systems Requirements Methodology for Long Duration Apollo Logistics Spacecraft, *H. S. ALEXANDER, North American Rockwell, Inc.*
- XIIID.4 Operations Research and Satellite Control Networks, *COL. P. S. SKARTVEDT, Air Force Satellite Control Facility.*

FRIDAY, JUNE 20, 8:30-10:15 AM

Bonanza (C)

XIIIE. Astronaut Activities and Space Tools – I

Chairman: Maj. C. E. WHITSETT, JR., *MSC, NASA.*

Co-Chairman: GEORGE W. SMITH, *Manager of Systems Research Dept., Martin Marietta Corporation, Denver.*

- XIIIE.1 AAP Crew/Cargo Translation Concepts, *GERALD J. WALKER, Office of Manned Space Flight, Hdqr. NASA.*
- XIIIE.2 Maneuvering Unit Development Programs, *HAROLD J. McMANN, NASA, MSC.*
- XIIIE.3 Astronaut Worksite Performance Evaluation Program, *DAVID G. NORMAN, General Electric Co., Valley Forge, Pa.*
- XIIIE.4 State of the Art of Space Tools—EVA/IVA, *CHARLES C. KUBOKAWA, NASA-Ames Research Center.*

FRIDAY, JUNE 20, 8:30-10:15 AM

Coronet (B)

XIIIF. Operations Research in Education – I

Chairman: DONALD P. GAVER, *Carnegie-Mellon University, and Westinghouse Electric Corporation.*

- XIIIF.1 Budget Allocations for New Faculty Positions, *JONATHAN HALPERN, Ford Foundation.*
- XIIIF.2 A Constant Work Model for Student Enrollment and Attendance, *KNEALE T. MARSHALL, Naval Post Grad. School; ROBERT M. OLIVER, University of California.*
- XIIIF.3 The use of Mathematical Programming Techniques in Designing School Finance Systems, *JAMES E. BRUNO, UCLA, The Rand Corporation.*

FRIDAY, JUNE 20, 8:30-10:15 AM

Broadway Arms (C)

XIIIG. Commercial OR Applications –I

Chairman: WILLIAM R. JEFFERSON, *Gates Rubber Company, Denver.*

- XIIIG.1 Economic Order Quantities for Multiple Set-Up Costs, STEVEN A. LIPPMAN, *University of California.*
- XIIIG.2 Making Short Run Changes in Production when the Employment Level is Fixed, MATTHEW J. SOBEL, *Yale University.*
- XIIIG.3 Some New Models for Inventory and Production Planning Operations, I. ILHAMI KARAYALCIN, *Garanti Blokleri B-5, Etiler-Istanbul, Turkey.*
- XIIIG.4 A Quantitative Approach to the Span of Control Problem, I. ILHAMI KARAYALCIN, *Garanti Blokleri B-5, Etiler-Istanbul, Turkey.*
- XIIIG.5 Evaluation of Organization Criteria, I. ILHAMI KARAYALCIN, *Garanti Blokleri B-5, Etiler-Istanbul, Turkey.*

FRIDAY, JUNE 20, 8:30-10:15AM

Onyx (B)

XIIII. Lunar Geological Experiments – I

Chairman. GORDON SWAN, *Center of Astrogeology, U.S. Geological Survey, Flagstaff, Ariz.*

Co-Chairman: E. J. ZELLER, *Department of Geology, University of Kansas.*

- XIIII.1 Physical Lunar Parameters Via Radio Tracking of Space Probes, P. M. MULLER and W. L. SJOGREN, *JPL.*
- XIIII.2 Apollo Lunar Geology Experiment, M. H. HAIT, JR., *U.S. Geological Survey.*

FRIDAY, JUNE 20, 8:30-10:15 AM

Gold (B)

XIIIJ. Maintainability and Reliability-I

Chairman: K. D. WOOD, *Prof. Aerospace Engineering, University of Colorado*

- XIIIJ.1 A New Dimension to In-Flight Maintenance Capability Via Hardware Design (Two Year Life Support System), DALE E. SPOND, *Martin Marietta Corp.; DONALD G. FULLERTON, Martin Marietta Corp., Denver*
- XIIIJ.2 Symbol-Oriented Approach to Automated Failure Analysis, W. W. HAPP, *NASA/Electronics Research Center.*
- XIIIJ.3 On Evaluating the Operational Performance of Digital Circuits, ARTHUR W. LO, *Princeton University.*
- XIIIJ.4 Integrated Circuits, Reliability and Testing, JEFFREY J. BOWE, *NASA/Electronics Research Center.*

FRIDAY, JUNE 20, 10:15-12:00 AM

Century (C)

**XIVA. Space Applications:
Communication and Data Transfer**

Chairman: BEARDSLEY GRAHAM, Consultant, Washington.

Co-Chairman: COL. GAGE CROCKER, Commander, Frank J. Seiler Research Laboratory, Office of Aerospace Research, USAF Academy.

- XIVA.1 Space Communication, Planning, Policy, and People, ROBERT BUTTON, COMSAT, Washington, D. C.
XIVA.2 Earth Benefits and System Restraints, JARED S. SMITH, General Electric Co.
XIVA.3 Space Science for Global Data Management, KERNS H. POWERS, RCA David Sarnoff Research Center, Princeton, New Jersey.

FRIDAY, JUNE 20, 10:15-12:00 AM

Ballroom (B)

XIVB. Management of Health Resources

Chairman: ROYAL A. CRYSTAL, Chief of Community Profile Data Center, United States Public Health Services.

Co-Chairman: JERRY GIEBINK, Co-Chairman, Denver Health Research Foundation.

- XIVB.1 Group-Practice and Efficient Health Services Delivery, EDWARD L. DOLINSKY, USPHS.
XIVB.2 Health Data Systems in the Offing: A Statistical Approach, OSWALD K. SAGEN, USPHS.
XIVB.3 Imperatives for Health Systems Research, MERWYN R. GREENLECK, Kaiser Foundation Hospital, Portland.
XIVB.4 CORE City Health Care—A Resource Management Challenge, DAVID L. COWEN, Denver Department of Health & Hospitals.

FRIDAY, JUNE 20, 10:15-12:00 AM

Stratton/Tabor (B)

XIVC. Space Medicine and Human Factors (AIBS)

Chairman: STANLEY DEUTSCH, Chief, Man-Systems Technology, Advanced Research and Technology, NASA/Hq.

Co-Chairman: DAVID W. STUBBS, Chief, Crew Systems Integration, Apollo Application Program, Martin Marietta Corp.

- XIVC.1 Space Medicine, CHARLES A. BERRY, MSC, NASA.
XIVC.2 New Technologies for Human Decision Making, WARD EDWARDS, University of Michigan.
XIVC.3 Architectural Psychology, CALVIN W. TAYLOR, University of Utah.
XIVC.4 Performance Prediction Techniques, EDWARD C. WORTZ, AiResearch Division, Garrett Corp.
XIVC.5 Perception of Laser Light, CARL F. ASIALA, JR., McDonnell Douglas, St. Louis.

FRIDAY, JUNE 20, 10:15-12:00 AM

Empire (C)

XIVD. ORSA Space Sciences II: NASA Costing Techniques and Their Applications

Chairman: HUMBOLDT C. MANDELL, NASA Manned Spacecraft Center, Houston.

Co-Chairman: RICHARD M. DAVIS, Martin Marietta Corp., Denver.

- XIVD.1 Contractor Basic Accounting Records as a Data Source for Cost Analysis, JOSEPH STRING, The Rand Corp.
- XIVD.2 Cost—A Basic Design Parameter, L. M. McKAY, McDonnell Douglas Astronautics.
- XIVD.3 Econometric Analysis of Earth Orbital Transportation Systems, CAREY RUTLAND, MSFC, NASA.
- XIVD.4 Manned Space Flight Information Network Extension System and its Application for General Systems Cost Modeling, R. C. TUEY, NASA OMSF.

FRIDAY, JUNE 20, 10:15-12:00 AM

Bonanza (C)

XIVE. Astronaut Activity and Space Tools — II

Chairman: Maj. C. E. WHITSETT, JR., MSC, NASA

Co-Chairman: GEORGE W. SMITH, Manager of Systems Research Dept., Martin Marietta Corp.

- XIVE.1 Problems of Abort from Manned Spacecraft, A. L. GREENSITE, General Dynamics/Convair.
- XIVE.2 EVA/IVA Flexible Lightweight Umbilicals, D. A. MYERS & H. J. RICHTER, Martin Marietta Corp.
- XIVE.3 Spacecraft Habitability for Future Manned Missions, R. B. WEBER and J. D. GATTS, Martin Marietta Corp.
- XIVE.4 EVA Stabilization Shoes, A. L. GREENSITE and E. H. WRENCH, General Dynamics/Convair.
- XIVE.5 Gravity Independent Liquid Collection and Fluid Phase Separation System, W. E. JAMES and D. J. HOLECEK, Martin Marietta Corp.

FRIDAY, JUNE 20, 10:15-12:00 AM

Coronet (B)

XIVF. Operations Research in Education — II

Chairman: DONALD P. GAVER, Statistics Department, Carnegie-Mellon University, and Westinghouse Electric Corp.

- XIVF.1 Stability of University Input Coefficients, DAVID BRENNEMAN and DAVID HOPKINS, Ford Foundation Project, Univ. of Calif., Berkeley
- XIVF.2 Mathematical Models for Classrooms Utilizing Individualized Instruction, DONALD P. GAVER, Carnegie-Mellon University.
- XIVF.3 Non—Tenure Faculty Appointment and Retention, ROBERT STANFORD and ROBERT M. OLIVER, Univ. of Calif, Berkeley, Ford Foundation Project.

FRIDAY, JUNE 20, 10:15-12:00 AM

Broadway Arms (C)

XIVG. Field Testing of OR Models

Chairman: JOHN D. KETTELLE, Chairman of the Board, The John D. Kettelle Corp.

Co-Chairman: GLENN G. FOSTER, Manager of Operations Analysis, The John D. Kettelle Corp.

XIVG.1 Modeling Air Antisubmarine Tactics with Data, FREDERICK G. STAHL, The John D. Kettelle Corp.

XIVG.2 Field Tests of Operations Research Models, A. S. BOLTHOUSE and A. M. JOHNSON, IBM Federal Systems Div.

XIVG.3 Statistical Methods of Model Validation, LT. J. M. ARRISON, III, Naval Postgraduate School, Monterey, Calif.

FRIDAY, JUNE 20, 10:15-12:00 AM

Onyx (B)

XIVH. Lunar Geological Experiments – II

Chairman: E. J. ZELLER, Department of Geology, University of Kansas.

Co-Chairman: GORDON SWAN, Center of Astrogeology, U.S. Geological Survey, Cedar, Arizona.

XIVH.1 The Lunar Receiving Laboratory, T. H. FOSS, Manned Spacecraft Center, NASA.

XIVH.2 Post-Apollo Lunar Geologic Exploration, A. H. CHIDESTER, JR., U.S. Geological Survey.

FRIDAY, JUNE 20, 12:00-1:45 PM

Silver Glade (C)

LUNCHEON

Panel: The Future of the Space Program

Moderator. EUGENE B. KONECCI, Pres. American Astronautical Society
CONGRESSMAN WAYNE ASPINALL (invited)
CONGRESSMAN GEORGE MILLER
JACK CARLSON, Deputy Director, Bureau of the Budget
WELDON B. GIBSON, Exec. V.P., Stanford Research Inst.
BRIG. GEN. W. R. HEDRICK, JR., Dept. of Air Force

FRIDAY, JUNE 20, 1:45-3:15 PM

Century (C)

XVA. Commercial Utilization of Space*Chairman: WALTER HAEUSSERMANN, MSFC, NASA.**Co-Chairman: RICHARDS ORD MORGAN, Denver Research Institute.*

- XVA.1 Potential Contributions of Orbital Earth Resources Data to Urban Planning, *CHARLES T. N. PALUDAN, MSFC, NASA.*
- XVA.2 From Space Technology to Profits, *M. F. RUDY, North American Rockwell.*
- XVA.3 Space Photography—Window to Discovery, *WILLIAM V. TROLLINGER, Trollinger-Gosney and Associates, Inc., Denver.*
- XVA.4 Manufacturing in Space: Low and Zero Gravity Manufacturing in Orbit, *HANS F. WUENSCHER, MSFC, NASA.*
- XVA.5 An Earth Resources Satellite, *B. P. MILLER, RCA Astro-Electronics Division.*

FRIDAY, JUNE 20, 1:45-3:15 PM

Ballroom (B)

XVB. Management of Power and Energy Resources*Chairman: L. M. ROBERTSON, Vice President Engineering (Retired), Public Service Company, Colorado.**Co-Chairman: EDWIN CRABTREE, Director, Colorado School of Mines, Research Foundation.*

- XVB.1 Management of Power and Energy Resources, *EARL EWALD, Northern States Power Co.*
- XVB.2 Management of Well Information for the Petroleum Industry, *JAMES M. FORGOTSON, Jr., Petroleum Information Corp., Denver.*
- XVB.3 Management of Waste Heat Discharges of Power Facilities, *N. S. LYNN and L. W. ROSS, University of Denver.*

FRIDAY, JUNE 20, 1:45-3:15 PM

Coronet (B)

XVC. Space Program Management and Mission Planning — I*Chairman: JOHN H. DISHER, Deputy Director, Apollo Applications Program, NASA Headquarters.**Co-Chairman: JOHN M. McCORKLE, Martin Marietta Corp., Denver.*

- XVC.1 The Impact of Apollo Applications on Space Station Engineering, *W. D. GREEN, NASA.*
- XVC.2 Manned Exploration of Mars and Venus Using Chemical Propulsion, *RICHARD R. TITUS, United Aircraft Research Labs.*
- XVC.3 Alternate and Backup Planning as a Function of the Probability of Successfully Achieving Preplanned Mission Objectives, *E. H. BAUER and E. F. FLEISCHMAN, MSFC, NASA*
- XVC.4 Technology Flow for Future Space Activities, *C. A. BRAUNWARTH, Martin Marietta Corp.*

FRIDAY, JUNE 20, 1:45-3:15 PM

Empire (C)

XVD. Commercial OR Applications – II

Chairman. *BERTEL W. KLEERUP, Management Services Supervisor, Ernst and Ernst, Chicago.*

Co-Chairman. *WILLIAM JEFFERSON, Gates Rubber Co., Denver*

XVD.1 Computers and Their Role in the Successful Development and Implementation of Operations Research Models, *RALPH ORAVEC, Price-Waterhouse and Company, New York.*

XVD.2 Seven Days in May—An Accurate Forecast of Weekly Cash Position a Year in Advance, *ALAN M. CUNNINGHAM, Touche, Ross, Baily and Smart, Denver.*

XVD.3 Long Range Facility Planning, *HAROLD DAVIDSON, Arthur Young and Co., Bethesda.*

XVD.4 Selling Operations Research to Management, *ROBERT M. DONALDSON, A. T. KEARNY and Co., Los Angeles, Calif.*

FRIDAY, JUNE 20, 1:45-3:15 PM

Holiday (C)

XVE. Astronautical Education and History

Chairman: *JAMES ALLEN, Chairman, History Dept., University of Colo.*

Co-Chairman: *SIDNEY L. RUSSAK, Martin Marietta Corp.*

XVE.1 Educating for the RFP, *P. LEVINE, AVCO Space Systems Division, and Brown University.*

XVE.2 Lunar Landing Decisions in American Decision Making, *JOHN LOGSDON, Dept. of Government, Catholic University, Washington, D.C.*

XVE.3 An Historical Note in the Genesis of Manned Planetary Flight, *ROBERT B. MERRIFIELD, NASA Manned Spacecraft Center, Houston, Texas.*

XVE.4 To be Announced.

FRIDAY, JUNE 20, 1:45-3:15 PM

Bonanza (C)

XVF. Operations Research in Education – III

Chairman: *ROBERT M. OLIVER, Office of Vice President, Planning and Analysis, University of California.*

XVF.1 Redirection Policies at Campuses of the University of California, *KNEALE T. MARSHALL, Dept. of O.A., Naval Postgraduate School.*

XVF.2 Macro-Analysis of the American Education System, *ALEXANDER M. MOOD, University of California.*

XVF.3 Expansion of University Facilities to Accommodate Increasing Enrollments, *ROBERT SANDERSON, Univ. of Calif., Ford Foundation Project.*

XVF.4 Post-Secondary Education for Disadvantaged—Analysis of Alternatives, *MIKLOS WASS de CZEGE, Research and Development Section, State of Wisconsin.*

FRIDAY, JUNE 20, 1:45-3:15PM

Gold (B)

XVG. OR in Public Systems – I*Chairman: PAUL MERRY, School of Business, University of Denver.*

- XVG.1** OR Model of Abatement Allocation, *R. B. SHAIN, Management Technology, Washington.*
- XVG.2** On a Theory of Accessibility for Selected Neighborhood Services, *G. L. PETERSON, Northwestern University; R. D. WORALL, Peat, Marwick, Livingston and Company, Washington.*
- XVG.3** Toward a Metric for Evaluating the Impact of Urban Highway Construction on Neighborhood Structure, *R. D. WORALL and R. ELLIS, Peat, Marwick, Livingston and Company; G. L. PETERSON, Northwestern University.*
- XVG.4** Survey of Changing Trends in Social Institutions, *ROBERT W. KNAPP, University of Colorado.*
- XVG.5** Structuring and Dimensioning Urban Activity Models, *EDWARD F. SULLIVAN, Tri-State Transportation Commission, New York.*
- XVG.6** Cost Effectiveness of Health and Welfare Programs, The Case of Child Health Care, *TEH-WEI HU, Pennsylvania State Univ.*

FRIDAY, JUNE 20, 1:45-3:15 PM

Broadway Arms (C)

XVH. Lunar Geological Experiments – III*Chairman: GORDON SWAN, Center of Astrogeology, U.S. Geological Survey, Flagstaff, Ariz.**Co-Chairman: E. J. ZELLER, Department of Geology, University of Kansas.*

- XVH.1** Lunar Traverse Geophysics in the Post-Apollo Time Frame, *J. S. WATKINS, University of North Carolina.*
- XVH.2** Electromagnetic Experiments at the Lunar Surface, *J. B. ARNETT and G. C. HENDERSON, General Dynamics Corp.; A. J. HOFFMAN, Texas Christian University.*

FRIDAY, JUNE 20, 1:45-3:15 PM

Stratton/Taber (B)

XVJ. Astronaut Activities and Space Tools – III*Chairman: MAJ. C. E. WHITSETT, JR., NASA, MSC.**Co-Chairman. GEORGE W. SMITH, Manager of Systems Research Department, Martin Marietta Corp., Denver.*

- XVJ.1** Astronaut Dynamics, *J. ROBERT TEWELL and CHARLES H. JOHNSON, Martin Marietta Corp., Denver.*
- XVJ.2** EVA maneuvering Unit Comparison, *MAJ. C. E. WHITSETT, JR., NASA, MSC; ALLWIN E. WUDELL and WILLIAN H. TOBEY, Martin Marietta Corp., Denver.*
- XVJ.3** Orbital EVA, *KENNETH SHEFFIELD, Martin Marietta Corp., Denver*

FRIDAY, JUNE 20, 3:15-5:00 PM

Century (C)

XVIA. Space Flight Safety

Chairman: JEROME LEDERER, Director, Manned Space Flight Safety Office, NASA.

Co-Chairman: RICHARD W. DRAKE, Chief, Systems Safety, Apollo Applications Program, Martin Marietta Corp., Denver.

XVIA.1 Safety for Large Space Stations, JACK W. WILD, NASA.

XVIA.2 Safety Technology Support for Large Space Stations, IRV PINKEL, Lewis Research Center, NASA.

XVIA.3 Looking Ahead Unmanned Spacecraft Systems Safety, L. C. MONTGOMERY, JPL.

XVIA.4 System Safety for Astronaut Maneuvering Units, GEORGE B. MUMMA, Martin Marietta Corp., Denver.

XVIA.5 Advanced Systems Safety, PHILIP H. BOLGER, NASA.

FRIDAY, JUNE 20, 3:15-5:00 PM

Ballroom (B)

XVIB. Management of Wastes and Pollutants

Chairman: DAVE DOMINICK, Commissioner Federal Water Pollution Control Ad., U.S. Department of Interior, Washington, D.C.

Co-Chairman: ELMER CHENAULT, Martin Marietta Corp., Denver.

XVIB.1 The Role of Nitrogen Oxides from Automobiles in Smog, RICHARD D. CADLE, National Center of Atmospheric Research.

XVIB.2 Follow the Leader—To Pollution Control, KEITH J. SCHLAGER, Colorado State University.

XVIB.3 The Restoration of Natural Waterbodies, HAROLD ANTHONY, and GEORGE P. FULTON, Martin Marietta Corp., Denver.

XVIB.4 Denver's Pollution Problems, WAYLAND J. WALKER, Denver Regional Council of Governments.

XVIB.5 Industry's Role in Air Pollution Abatement Programs, LLOYD T. JENSEN, Great Western Sugar Company, Denver.

XVIB.6 An Evaluation of the Use of Systems Analysis to Solve a Waste Management Problem, IRWIN PRICE and DAVID H. STIMSON, University of California.

XVIB.7 Regional Air Pollution Analysis, M. L. FRANKEL, TRW Systems.

FRIDAY, JUNE 20, 3:15-5:00 PM

Empire (C)

XVID. Commercial OR Applications – III*Chairman: R. B. GRANT, Vice-President, New York Stock Exchange.**Co-Chairman. R. C. HEARD, Gates Rubber Co., Denver.*

- XVID.1 Conditions for Success (and Failure) in OR Applications, *LELAND A. MOODY, Arthur Anderson & Co., Chicago, Ill.*
- XVID.2 Comparison of Forecasting Techniques, *JOE BULAT, Burroughs Corp.*
- XVID.3 Costing Techniques and Models, *THOMAS J. McCARTHY, Lybrand Ross Bros. & Montgomery, New York.*
- XVID.4 Scheduling and Forecasting, *RAYMOND D. REISERT, JR., Lybrand Ross Bros. & Montgomery, New York.*
- XVID.5 Optimum Operations of a Tandem Rolling Mill, *C. F. WANG, University of Pittsburgh.*

FRIDAY, JUNE 20, 3:15-5:00 PM

Bonanza (C)

XVIE. Military OR V*Chairman: RICHARD H. BLYTHE, Director, Operations Analysis, NORAD., Colo. Springs, Colo.*

- XVIE.1 Attrition Rates for Probabilistic Combat Models, *S. R. KIMBLETON, University of Michigan.*
- XVIE.2 Evaluation of V/STOL Aircraft in a Multi-Mission Scenario Using Statistical Distributions for Mission Frequencies, *DILIP R. LIMAYE, The Boeing Company, Philadelphia.*
- XVIE.3 Graphic Comparison of Cost Effectiveness in a Multi-Mission Scenario, *DILIP R. LIMAYE, The Boeing Company, Philadelphia.*
- XVIE.4 Assessment of Weapons System Effectiveness with Combined Monte Carlo-Expected Value Type Simulations, *J. C. STAMPER and G. L. GALLAGHER, General Dynamics Corp.*
- XVIE.5 Possibility of Producing a Dense Thermonuclear Plasma by an Intense Field Emission Discharge, *F. WINTERBERG, University of Nevada.*

FRIDAY, JUNE 20, 3:15-5:00 PM

Holiday (C)

XVIF. Maintainability and Reliability – II*Chairman: ROBERT FLAGRADY, Computer Sharing Services, Denver, Colo.*

- XVIF.1 Optimal System for Reliability for an Arbitrary Structure, *RICHARD M. BURTON and GILBERT T. HOWARD, U.S. Naval Postgraduate School.*
- XVIF.2 Application of The Learning Curve to Maintainability Tests and Demonstrations, *ROBERT L. STREET, Texas A&M University.*
- XVIF.3 On-Line Reliability Concept, *JOHN P. HORNING, Technical Operations, Inc., Burlington, Mass.*
- XVIF.4 Two Simulation Models for Planning and Evaluating Aircraft Avionics Maintenance Systems, *ALAN P. FEDDERSEN, University of California.*

FRIDAY, JUNE 20, 3:15-5:00 PM

Gold (B)

XVIG. OR in Public Systems II

Chairman: G. C. CLEMENTSON, *Management Consultant, Autotronics Universal Corp., Denver.*

- XVIG.1 A Stochastic Model for the Analysis of Epidemics, *MICHAEL E. THOMAS, University of Florida.*
- XVIG.2 An Information System for State Health Planning, *W. R. BRIAN CARUTH, Southwest Research Institute.*
- XVIG.3 Planning and Analysis for Higher Education—Promises and Pitfalls, *PAUL W. HAMELMAN, West Virginia University; J. DOUGLAS MACHESNEY, West Virginia Commission on Higher Education.*
- XVIG.4 An Assessment of the Contribution of Operations Research to Educational Planning, *HAROLD WEITZ, IBM Corporation.*
- XVIG.5 Joint Production and Cost Functions for a Big City High School System, *THOMAS G. FOX, Pennsylvania State University.*

FRIDAY, JUNE 20, 3:15-5:00 PM

Broadway Arms (C)

XVIH. Lunar Geological Experiments – IV

Chairman: E. J. ZELLER, *Department of Geology, University of Kansas.*

General Discussion

This Session will be a general discussion session wherein all authors of papers on lunar geology and the lunar surface will be invited to speak and present their various views, at a time shortly before the planned lunar landing. The Chairman will lead the discussion.

FRIDAY, JUNE 20, 3:15-5:00 PM

Stratton/Tabor (B)

XVIJ. Decision Theory Applications

Chairman: W. W. WHITMAN, *Professor of Mathematics, Colorado School of Mines, Golden, Colo.*

- XVIJ.1 Application of Bayesian Decision Theory to Large Fire Control Systems, *JAMES B. DAVIS, U.S. Forest Fire Service, Riverside, Calif.*
- XVIJ.2 Aerospace Technology and Urban "Disorders", *CLARENCE J. HARRIS, General Electric Company.*
- XVIJ.3 Subjective Measures of Merit Involving Multiple Criteria of Evaluation, *LEE H. SMITH, University of Texas.*
- XVIJ.4 A Non-Stationary Probability Diffusion Model for Consumer Brand Choice Behavior, *J. MORGAN JONES, Graduate School of Business, UCLA.*

FRIDAY, JUNE 20, 3:15-5:00 PM

Coronet (B)

**XVIK. Space Program Management
and Mission Planning – II**

Chairman: *JOHN H. DISHER, Deputy Director, Apollo Applications Program, NASA Headquarters.*

Co-Chairman: *JOHN M. McCORKLE, Martin Marietta Corp., Denver.*

- XVIK.1 A Methodology to Compare Policies for Exploring the Solar System, *ROBERT G. CHAMBERLAIN and LOUIS KINGSLAND, JR., JPL.*
- XVIK.2 Planning Future Information Transfer Missions, *EDGAR M. VanVLECK, NASA Mission Analysis Division.*
- XVIK.3 The Challenge of Providing the Public with Economical Space Transportation by the Year 1980, *HENRY G. EDLER, National Aeronautics and Space Council, White House Mail Room, Washington.*

FRIDAY, JUNE 20, 3:15-5:00 PM

Leadville (B)

XVIL. Astronaut Activity and Space Tools – III

Chairman: *To be Announced.*

- XVIL.1 Problems of Abort from Manned Spacecraft, *A. L. GREENSITE, General Dynamics/Convair.*
- XVIL.2 EVA/IVA Flexible Lightweight Umbilicals, *D. A. MYERS and H. J. RICHTER, Martin Marietta Corp.*
- XVIL.3 Spacecraft Habitability for Future Manned Missions, *R. B. WEBER and J. D. GATTS, Martin Marietta Corp.*
- XVIL.4 EVA Stabilization Shoes, *A. L. GREENSITE and E. H. WRENCH, General Dynamics/Convair.*
- XVIL.5 Gravity Independent Liquid Collection and Fuel Phase Separation System, *W. E. JAMES and D. J. HOLECEK, Martin Marietta Corp.*

ABSTRACTS

IA.1 Future Manned and Automated Earth Orbital Science Missions, *HENRY J. SMITH, Deputy Administrator, Science, NASA, Wash., D. C. 20546.*

The second decade of Earth orbital space science will capitalize on discoveries of the first generation of Explorer and observatory satellites. Specialized scientific satellites will complete the description of the space environment to develop a complete understanding of the physical processes at work. Great observatories will be erected and spaced as permanent facilities to study remote astronomical objects, as well as nearby Earth. The unique research environment of perfect vacuum and total absence of gravity forces will open up new disciplines of physical and biological sciences to be pursued in orbiting space laboratories.

IB.1 The Soft Data Problem: A Case Study of Education, *MICHAEL H. HALBERT, Institute for the Study of Inquiring Systems, 3401 Market St., Phila., Pa. 19104.*

In the field of education, as in many other fields, the measurement and interpretation of attitudes, perceptions, preferences, feeling tones, etc. presents special problems. Most of the measurement models assume at least interval scale data and often assume interpersonal comparability. Recently the psychometric field of non-metric scaling has permitted much more realistic models of inter- and intra-personal processes. This paper presents a use of these techniques to define and measure the attitudes of 3,000 Pennsylvanians toward the schools in their state. The stimuli used were photographs and the response required was a set of sortings. There were *no* verbal responses. The analysis showed the kind, amount, and structure of their feelings.

IB.2 Problems of Managing Criminal Justice, *ROBERT D. TRUJILLO, Director, Department of Probation Services, County Court, City and County Building, Denver, Colorado 80202.*

The operation of the social system commonly referred to as Criminal Justice is receiving a great deal of well deserved attention. The administration of justice in our culture has become a near deified entity because of the enormous concern with individual freedom which is a cornerstone of the national political structure. In the wake of the application of American Criminal Justice a number of sub-systems has developed which has further divided to produce a conglomerate process which has to date defied original internal validity or functional validity. It is necessary to identify, classify and validate components of the system in order to justify guidelines for revision. It shall be the intent of this presentation to establish problem areas worthy of investigation.

IB.3 Development of a Central Information System within the Context of a Model Cities Program: Opportunities and Obstacles, *FRANCIS G. CARO, Assistant Director for Evaluative Research Institute of Behavioral Science, University of Colorado, Boulder, Colo. 80302.*

The planning of Denver's Model Cities Program provided the occasion for an attempt to develop an information system including major public and private social service and control agencies. In spite of benefits which the system would have provided for social planners, the effort to develop the information system was abandoned. The paper examines some of the basic social forces operating within the organized community generally and within the Model Cities program specifically which effectively blocked the project. Some community conditions which must be established before a central information system can be implemented are identified.

IB.4 Frontiers in the Planning and Management of Mental Institutions, *PAUL R. BINNER, Chief, Research Department, Fort Logan Mental Health Center, Denver, Colorado 80236.*

In recent years, the mental health field has made substantial gains in rapidly treating and returning to the community increasing numbers of patients. After decades of steadily rising state hospital resident populations, there has been a nationwide decline in those populations, in spite of sharply increased numbers of admissions. This paper examines some of the resulting issues in the planning and management of mental institutions that must be dealt with if we are to maintain and accelerate these recently won gains. These include a reconsideration of program goals and a modernization and broadening of institutional information systems for better monitoring and evaluation of mental health systems.

IB.5 An Analytical Model of a Welfare Caseload, *HAROLD A. MORSE, Supervisor, Research and Statistics, Dept. of Welfare, 777 Cherokee Street, Denver, Colorado 80204.*

An inventory for evaluating the potential of welfare families for economic independence, based on the family caseworker's observations and judgments, is described. An analytical model of a stable caseload with a one-third annual turnover is constructed. The model assumes no change in potential for self-support during the period a family is on welfare. Thus, the distribution of scores for cases closed would be identical to that for cases added for the model. Therefore, the effects of social services on the caseload can be measured in a single year by comparing the initial inventory scores for cases added with the final scores for cases closed. It is indicated that the net effect of social services is improvement in inventory scores and that this improvement is pertinent to improved prospects for self-support.

IC.1 Liability for Space Activities, *PROF. VED P. NANDA, College of Law, University of Denver, Denver, Colorado 80204.*

The paper will deal with the question of liability for personal and property damage caused by space activities. Assuming that the law of strict liability should be applicable, the paper will inquire into the desirability of including some exonerations from strict liability into an international agreement.

IC.2 Space Law—Polar Research as a Model for Space Activities, *JOHN C. EVANS, JR., NASA Lewis Research Center, Cleveland, Ohio 44135.*

Apollo 8 has carried man to the Moon. The time draws near for the establishment of Lunar and planetary stations. In many ways the international legal problems of these will parallel those of the polar programs. Taking a lesson from the history of the American colonization may avoid conflicts when the information gathering phase changes into the resources-exploitation period.

IC.3 Prospects for Space Law, *MAJ. ALAN HERMAN, U.S. Air Force Academy, Colorado Springs, Colorado 80840.*

Implications for science and technology of the "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies" will be discussed. It will focus on what scientists can look forward to as the legal framework within which they will be required to operate, i.e., The "Do's" and "Don'ts" of outer space.

IC.4 Evolution of Space Treaties, *PAUL B. DEMBLING, General Counsel, NASA, Washington, D. C. 20546.*

The paper will focus on the evolution of the "Outer Space Treaty," and the "Treaty on Return and Rescue of Astronauts and Space Objects," and questions pertaining to the interpretation of these treaties.

ID.1 Mathematical Model for Aerospace Maintenance, *C. M. RIEHL, North American Aviation, Inc., Space Division, 12214 Lakewood Boulevard, GB22, Downey, California 90241.*

This paper presents the results of an effort to develop a generalized digital computer simulation model of a maintenance sub-system required to support any given aerospace system. Model scope is concerned with both prelaunch activities performed and post-launch activity. Modeling attention has been focused on producing quantitative information regarding the operation of the maintenance system in response to demands placed on it. It also provides a measure of the maintenance system's efficiency, performance and cost during this operating period.

ID.2 A General Description of an Environmental Information Systems Program, *STEVEN H. COHEN, Office of Atmospheric Water Resources, Bureau of Reclamation, Denver, Colorado 80225, and WILLIAM A. PETERMAN, Denver Research Institute, University of Denver, Denver, Colorado 80210.*

Present meteorological systems are generally plagued by a wide variety of data format, inefficient use of communications, and time-consuming analysis techniques not designed to meet specific user requirements. The need for an integrated environmental information system and the adaption of a decision-making process to a variety of applied problems such as urban environment (including air pollution), weather modification operations, and air-traffic meteorological systems will be discussed. A description of the information and decision requirements of a national environmental system at various operational scales will also be given.

ID.3 Bayesian Risk Analysis by Decision Networks, *ANDREW VAZSONYI, Scientific Advisor, North American Rockwell Corporation, and University of Southern California, 3419 Bayview Drive, Manhattan Beach, California 90266.*

Current network analysis techniques optimize in terms of cost and time, but uncertainties are handled primarily on an intuitive basis. This deficiency in network theory can be remedied by a cost-time risk model. The central concept of the model is a family of time-cost risk surfaces which are efficient in the Pareto sense. Executive decision making is conceived as searching for good solutions by navigating within well-defined domains in the master Pareto surface. Optimization is achieved by man-machine IF-THEN dialogues supported by a real-time CRT tube-equipped geographically dispersed computer facility.

IE.3 No-Loss Cryogenic Storage on the Lunar Surface, *J. H. BELL, JR., The Boeing Company, Huntsville, Ala.*

Lunar exploration and extended lunar stay requires the capability of storing oxygen and hydrogen there for extended periods of time. A technique for storing these cryogenics for a period of 6 months to a year is described. This theory is based on the best cryogenic information available at this time. Under the Molab study contract NAS8-20073, a study was made to determine the best method of storing propellants on the lunar surface. The results of this study are also presented. Curves were plotted for optimizing the design, and equipment layouts are presented showing designs and materials selected for best results.

IF.2 BMEWS Operational Capability Testing, *HERMAN RABITCH, The John D. Kettelle Corporation, 12 N. Meade Ave., Colorado Springs, Colorado 80909.*

The Ballistic Missile Early Warning System (BMEWS) performs system capability tests at least once per shift. Two classes of testing are used, Real World and checkout testing. The formal data from satellites is used for Real World evaluation while in the latter case the data is generated by the system checkout computer (SCO). The manner in which SCO simulates radar returns from missiles and the way in which these are processed will be discussed. The figures of merit and statistical tests that are used to evaluate system capability will also be discussed. The Real World testing will be discussed in a similar context.

IG.2 Stochastic Inventory Models with State-Dependent Leadtimes, D. GROSS, C. M. HARRIS, and F. A. MIERCORT, *Research Analysis Corporation, McLean, Virginia 22101.*

This paper describes several one-for-one ordering (S-1,S) inventory models in which the mean order replenishment time depends on the number of orders outstanding. Queuing theory results are used to determine the optimal order level.

IIA.1 Results of Earth Resources Surveys of the Earth and Plans for Future Satellites, WILLIAM A. FISCHER, *U.S. Geological Survey, Office of the Director, U.S. Dept. of the Interior, Washington, D. C. 20242.*

Using randomly collected data from the Apollo, Gemini, and Mercury space flights, the U. S. Geological Survey has compiled photo mosaics, that are map-like in quality, of over 1,000,000 square miles of the Earth's surface. Geological Survey scientists have prepared: 1) a geologic terrain map of the southwest United States, 2) a land-use planning map, of the same region, a tectonic map, and soon will complete a land-use map of the area.

Many other tests have been made of the utility of space data. Comparison of Apollo photographs of the east coast of Georgia, with existing maps, suggests that space photography will have great utility in revising the maps of the constantly changing coastal areas and in delineating under-water topography.

IIA.2 Applications of Earth Orbital Remote Sensing to Forest and Range Problems, ROBERT N. COLWELL, *University of California, School of Forestry and Conservation, 145 Mulford Hall, Berkeley, California 94720.*

This paper first considers the informational requirements of those who seek to manage forest and range resources. Then it briefly considers the extent to which these requirements presently can be met through the use of conventional aerial photography that is flown to proper specifications in terms of film filter, scale, time of day and season of year. The remainder of paper considers examples which illustrate the potential applications of Earth orbital photography, and related remote sensing data, in acquiring information that will help solve forest and range problems.

IIA.3 Earth Resource Information Systems, J. RALPH SHAY, *Department of Botany and Plant Pathology, Oregon State University, Corvallis, Oregon.*

The summer study by the National Research Council on space systems for Earth resources information will be reviewed. With improved weather forecasting and storm warnings expected from the meteorological program, the potential benefits of more timely and accurate Earth resources information to resource managers will be large. However, extensive research and educational efforts must be expended to realize the potential of more sophisticated systems that can be realized within the decade of the 1970's. This research is viewed as one of the most important pacing elements in the development of the Earth resources program.

IIA.4 Aerospace Applications in Agriculture and Forestry, A. B. PARK, *Agricultural Research Service, U.S. Department of Agriculture, Washington, D. C. 20250.*

The Food and Agriculture Organization of the United Nations has stated that to provide a decent level of nutrition for the world's people, the production of food will have to be doubled by 1980 and trebled by 2000. The President's Science Advisory Committee published in May 1967 a *Report of the Panel of the World Food Supply*.

Opportunities for increasing and sustaining the productivity of the land and facilitating product flow in agriculture are identified and measured. The lack of information can be a major obstacle to the economic development of underdeveloped regions of the world and a subsequent obstacle to the formulation of important policies in more fully developed regions.

Multispectral sensors tested in high altitude aircraft are adaptable to spacecraft and in an appropriate orbit similar sensors can provide the necessary data. This paper discusses the kinds of information obtainable from the sensors and how this information is related to the agricultural resource problems.

IIA.5 Synoptic Oceanography. Remote Sensing Studies of the Ocean, *J. W. SHERMAN, Spacecraft Oceanography Project, Naval Oceanographic Office, Washington, D. C. 20390.*

The vastness of the oceans, the large-scale nature of many oceanic phenomena, and the slowness and expense of in-situ measurements point to a need for more rapid and continuous observations of the ocean. The need for greater perspective, and broader synoptic coverage are accelerating the development and use of remote oceanographic sensors from ships, aircraft and spaceborne platforms. The latter two platforms will receive the emphasis in this discussion.

IIB.2 The Use of Multi-State Input-Output Analysis in the Analysis of Population Flow Patterns, *RUSSELL C. KAZA, Assistant Professor of Management Science, University of Colorado, School of Business, Colorado Springs, Colorado 80907.*

The problem discussed in this paper is the determination of a student population flow pattern within a geographic region. The method of approach is a multi-stage input-output model which uniquely presents time dimensioned inter-activity matrices that allows analysis and potential determination of causal factors for temporal coefficient changes. The concepts and theoretical aspects of this technique were presented by the author at the ORSA-TIMS Spring '68 joint meeting. This paper reveals that the M/SI/O technique leads to a coherent description of population flow patterns, provides a workable framework for educational resource allocation decision-making, and may be linked with other models for projection purposes.

IIB.3 A Mathematical Theory for the Exploitation of Biological Populations, *STUART H. MANN, Purdue University, School of Industrial Engineering, Lafayette, Indiana 47907.*

A biological population is considered in which members of the population are harvested for value. Revenue and cost structures are defined for this system and a stochastic description of population growth is used in which changes in the distribution of growth are described by a Markovian distribution process. An operating policy is described that maximizes the expected economic gain to be realized in the duration of time during which management of the population anticipated.

IIC.1 The Pioneer Spacecraft Program, *GLENN A. REIFF, Manager Pioneer Program, NASA, Washington, D. C. 20546.*

Begun during 1958, the research program for developing and operating Pioneer spacecraft is one of the patriarchs of the space age. The first Pioneers helped pave the way to the Moon; the next was a Trailblazer into deep space; and the following series has established a network of interplanetary weather outposts. Challenging Pioneer missions through the Asteroidal Belt toward the vicinity of Jupiter are planned for the early 1970's. This paper summarizes the origins of the Pioneer Program, reviews selected scientific results, and gives a glimpse of future pioneering missions.

IIC.2 Pulsars—Observations and Theory, *STEPHEN P. MARAN, Solar Physics Branch, Laboratory for Space Sciences, Goddard Space Flight Center, Greenbelt, Maryland 20771.*

Observational data on time-dependent properties of pulsed optical and radio emission from pulsars are reviewed with special attention to phenomena observed in the Crab Nebula supernova remnant. The status of the theoretical problem, with emphasis on the nature of radiation generation and transport in the presence of intense magnetic fields is considered in connection with the neutron star hypothesis for pulsars and the origin of galactic cosmic rays.

IIC.3 High Energy Space Astronomy, *GEORGE W. CLARK, Massachusetts Institute of Technology, Cambridge, Mass. 02139.*

The high energy end of the electromagnetic spectrum from soft x-rays to high energy gamma rays has been opened to astronomical investigation by balloon, rocket and satellite experiments during the past decade. These exploratory efforts have shown that the new fields of x-ray and gamma ray astronomy are rich in observational material and unexpected discovery and are amenable to inventive instrumentation. Several new satellite experiments, now under construction or planned for the near future, will greatly extend the range and precision of the observations.

IIC.4 Solar Activity and Planetary Positions, *J. B. BLIZARD, University of Denver, Denver, Colorado.*

It is found empirically that solar activity is preceded by planetary conjunctions. A long-range prediction technique has been in use for 2½ years, which predicts flares and proton events far in advance. The method has predicted the dates and positions of over half of the proton events, using only five parameters: the orientation of four planets and of an active longitude on the Sun. The findings are based on observations and statistical tests, and are not dependent upon any theory. Nevertheless, there is general agreement between the results and hypotheses of planetary tidal effects. Although significant results are obtained using only four planets, a refinement of the technique might include other planets.

IIF.1 Search Theory in the Presence of False Contacts, *MARTIN AVERY SNYDER, Bryn Mawr College, Bryn Mawr, Pennsylvania 19010 and Daniel H. Wagner Associates, Paoli, Pennsylvania 19302, and LAWRENCE D. STONE, Daniel H. Wagner Associates, Paoli, Pennsylvania 19301.*

This paper discusses searches for stationary targets in the presence of false contacts. When there are two targets and one wishes to minimize the expected time to find the next target, the problem of when to switch from one search to another is considered. The *a posteriori* target location distribution is found for a search which has produced n contacts (indistinguishable from the target without further investigation) located at several points.

IIF.2 Problems in the Application of Visual Detection Models, *C. P. GREENING, Scientific Advisor, Research and Engineering Division, Autonetics Division, North American Rockwell Corporation, Anaheim, California 92803.*

Autonetics has developed an analytical model of the visual air-to-ground target detection process. This model was validated by comparison with the data obtained in a motion picture simulation. The validation study demonstrated the basic validity and accuracy of the model, but also disclosed the need for further refinements in the determination of parameters. The model and the validation study are described briefly, followed by a more detailed discussion of the problems associated with selection and estimation of parameters in the "real world."

IIF.3 Passive Surveillance Model, *R. L. KLINKNER and LLOYD F. BELL, Tetra Tech Corporation, Washington, D. C.*

The problem of estimating the location of a target detected by a distributed set of passive sensors is considered. The effects of stochastic fluctuation in the characteristics of the target and the medium and mixtures of different types of sensors in the set are discussed. A model, which utilizes Monte Carlo techniques to determine which sensors are in contact and then derives the best estimated position of the target, is presented.

IIF.4 A Problem in Optimal Search and Stop, *SHELDON M. ROSS, University of California, Berkeley, California 94720.*

We are told that an object is hidden in one of a number of boxes and we are given prior probabilities, $p(i)$, that the object is in box i . A search of box i costs $c(i)$ and finds the

object with probability $a(i)$ if the object is in the box. Also, we suppose that a reward $R(i)$ is earned if the object is found in box i . A strategy is any rule for determining when to search and if so which box. The major result is that an optimal strategy either searches a box with maximal value of $a(i)p(i)/c(i)$ or else it never searches those boxes. Also, if rewards are equal, then an optimal strategy either searches a box with maximal $a(i)p(i)/c(i)$ or else it stops.

IIF.5 A Simple Moving Target Search and the Golden Section, S. M. POLLOCK, Department of Operations Analysis, Naval Postgraduate School, Monterey, California 93940.

A target is allowed to move, in a known Markovian manner, between two regions. The search procedure that allocates discrete search efforts (looks) to minimize the expected number of looks needed for detection is obtained. This procedure, when the conditional detection probability is unity, is intimately dependent upon the golden section. Interesting computational results for other cases are discussed, and a general formulation for the Markovian-moving target model is presented.

IIG.1 Linear Programming, Spanning Trees, and the Traveling-Salesman Problem, MICHAEL HELD, IBM Systems Research Institute, New York, N. Y. 10001, and RICHARD M. KARP, University of California, Berkeley, California 94704.

This paper explores methods of exploiting the connection between the minimum spanning tree problem and the traveling-salesman problem to obtain exact or approximate solutions of the latter. Basic to these methods is a linear program solvable by column generation, requiring repeated solution of minimum spanning tree problems. The derivation of this program is carried out in a general setting which leads to a new interpretation and extension of the Dantzig-Wolfe decomposition technique for linear programs, and suggests further applications. Although limited experimental computations have been disappointing, the novelty and flexibility of the approach merit further investigation.

IIG.2 On Non-Parametric Sensitivity Analysis in Linear Programming, ROBERT N. BRASWELL, Professor and Chairman, and FRED MARSDEN ALLEN, Research Assistant, Department of Industrial and Systems Engineering, University of Florida.

Given a linear programming problem subject to random variation in one or more components of the requirements vector, but where the corresponding probability distributions are completely unknown, the problem can be solved deterministically using only crude estimates, then sensitivity analysis can be applied to determine the effect of random elements as they occur. Once the solution is implemented, however, there is usually an appreciable cost of modification. This paper establishes a criterion for actually changing a particular solution, based upon the notion of non-parametric tolerance limits. The results are extendable to both the cost vector and activity matrix.

IIG.3 On the Theory and Applications of Interval Linear Programming, A. BEN-ISRAEL, Northwestern University, Evanston, Ill. 60201 and P. ROBERS, Research Analysis Corp., McLean, Va. 22101.

The term "interval linear programming" (IP) refers to the theory, computations, and applications of problems having the objective of maximizing the functional c^*x , where c^* is the transpose of vector c , and where x satisfies the constraint that Ax lies between vectors a and b . Matrix A , and vectors a , b , c are given. (IP) is an alternate model for linear programming which offers the advantage of explicit solution in some instances. The required conditions for explicit solution of (IP) and an efficient algorithm for solving the general (IP) are summarized in this paper. Some applications in which interval linear programming may yield considerable computational economy are discussed.

IIIG.4 Set Covering with Equality Constraints*, *R. S. GARFINKEL and G.L. NEMHAUSER, The Johns Hopkins University, Baltimore, Maryland 21218.*

An enumerative type algorithm is given for set covering problems with equality constraints. The efficiency of the algorithm is demonstrated by the fact that most problems can be solved much more rapidly than the corresponding linear program. Computational results are given for real and randomly generated problems.

IIIB.1 Computerized Forest Management, *M. P. LAZARA, President, Greenacres, Inc., Seattle, Washington 98104.*

During the past centuries man has destroyed entire forests. In the process he has created wastelands, farms, or cities. A lack of knowledge rather than greed caused this profound change in the surface of the Earth.

Today, an interdisciplinary technological approach may solve this problem. It will give the professional forester a means of worldwide inventory, development, and management of the world's dwindling but renewable natural resources.

Satellite-borne remote sensors, supplemented by telemetering instrumentation and conventional photographic and ground information-gathering procedures, will deliver data to computer centers to be stored ready for many uses in data banks.

IIIB.2 Some Myths about World Hunger, and Why They Must be Dispelled, *ROBERT C. LIEBENOW, President, Corn Refiners Association, Inc., 1001 Connecticut Avenue, N.W., Washington, D. C. 20036.*

Too often the world hunger problem has been viewed—at least in this country—in terms of a crisis curable only by a panacea. This impression is highly misleading. And worse, it masks the only sensible course of action open to us: that of a broad scale attack in which recent developments in health, population control and crop production all are focused on the problem. We should recognize the fact that the development of the new miracle strains of rice, wheat and high-protein corn do not represent “the answer.” Neither does effective new methods of birth control. We also must recognize that programs to improve health and nutrition do not compete with programs that seek to control the rate of birth. Only a broad scale effort can dispel the spectre of an Earth populated in the year 2000 by more than seven billion persons—a world in which hunger and malnutrition will represent an even greater problem than today.

IIIB.3 Microbes as a New Source of Food for the Expanding World Population, *D. M. UPDEGRAFF, Head, Microbiology Section, Denver Research Institute, University Park, Denver, Colorado 80210.*

The world is underfed at present. Students of economic geography and nutrition agree that approximately 2/3 of the world's people either do not get enough to eat, or do not receive food of proper nutritional quality. The most important deficiency in the diet of most people receiving food of inadequate quality is protein.

Fortunately a new source of high-quality protein, capable of meeting the world's needs for many decades, is at hand. This is microbial protein, or single-cell protein. Bacteria and fungi are capable of growing and synthesizing protein hundreds of thousands of times as rapidly as beef cattle, for example. Furthermore, they can use such cheap and abundant materials as kerosene and wood pulp as raw materials.

IIIB.4 Maximum Productivity from Industry-Owned Forest Lands, *JEROME L. CLUTTER and JAMES E. BETHUNE, School of Forest Resources, University of Georgia, Athens, Georgia 30601.*

Maximizing productivity of a renewable natural resource such as timber is complicated by

*Research supported in part, by CROND Inc. Wilmington, Delaware

the dual function of the forest. It is both an inventory of raw material and a factory for timber production. Optimum strategies for performing this combined inventory-production function must consider a complex association of biological and economic variables. This paper describes a set of procedures designed to (1) appraise each compartment of a forest under all feasible harvesting schedules, (2) select an optimum set of harvest strategies under constraints on product flow and harvesting and regeneration capabilities, and (3) project product and cash flows generated by the selected strategy.

IIIC.1 The Atmospheres of Jupiter and the Outer Planets, S. I. RASOOL, *Goddard Institute for Space Studies, New York, New York 10025.*

The structure of the atmosphere of Jupiter is discussed in light of some recent Earth-based infrared and microwave observations. Spacecraft experiments designed to resolve some of the more interesting problems are described. The atmospheric properties of the other outer planets are also discussed.

IIIC.2 The Atmosphere of Mars and the Mariner '69 UV Experiments, C. A. BARTH, F. C. WILSHUSEN, K. GAUSE, K. K. KELLEY, R. RUEHLE, J. B. PEARCE, C. W. HORD, *University of Colorado, LASP, Boulder, Colorado 80302*; W. G. FASTIE, *Johns Hopkins University, Baltimore, Maryland 21203*; E. F. MACKEY, *Packard-Bell Electronics Corp., Space & System Div., Newberry Park, Calif.*

Present knowledge of the atmosphere of Mars will be reviewed. The Mariner Mars '69 experiments will be described and the scientific expectations from the UV experiments will be discussed.

IIIC.3 Optical Properties of the Venus Atmosphere, ROLAND L. HULSTROM, *Marietta Corporation, Denver, Colorado 80201.*

The feasibility of using visual imaging devices to determine characteristics of the Venus atmosphere and surface requires an understanding of the optical properties of the Venus atmosphere. Recent Venus probes together with Earth-based observations have produced the necessary information for a preliminary determination of the transmission of light by the Venus atmosphere. A model Venus atmosphere was derived by extrapolating the measured Venus atmosphere adiabatically to the radar surface. Rayleigh scattering in this model atmosphere and diffusion theory applied to the Venus cloud are used to obtain intensity and hue of the light reaching the Venus surface.

IIID.1 Partitioning Algorithms in Mixed and Pseudo-Mixed Integer Programming, ARNAUD L. HENRY-LABORDERE, *IBM France (Paris).*

A natural partitioning procedure allows the decomposition of the mixed integer programming problem (MIP) into a pure integer master program and a linear programming subprogram. Two algorithms based on this partitioning are presented. The first finds a suboptimal solution to the MIP. A computer program implementing this algorithm was applied to the plant location problem. Results are presented and discussed. The second algorithm is particularly useful for finding an optimal solution to the Mask Set Selection problem (MIP, where the objective function involves only integer variables). A relationship to the 4-color problem is shown, and it is suggested to use this thesis' second algorithm to resolve the 4-color problem via computer.

IIID.2 An Application of Linear Integer Programming Using Two Simultaneous Objective Functions and Non-Linear Constraints, EDWARD K. KUTCHMA, *Mathematical Economics, University of Colorado, Boulder, Colo. 80302.*

The paper has three objectives. First, to demonstrate how a linear programming algorithm can use two simultaneous objective functions. Second, to illustrate how non-linear constraints can be adapted to a solution method which requires linearity. In particular, to show how a probability function can be linearized. Last, to exhibit a systems approach to cost analysis via the simplex method.

The vehicle for the demonstration of these objectives is the cost evaluation of an air interdiction situation. In this problem a least munitions cost, least aircraft loss solution must be found so that the type of aircraft, bombs, and delivery tactics to be used will be optimal in terms of both dollar cost and military efficiency.

IIID.3 A Network Isolation Algorithm, *M. BELLMORE, Asst. Professor of Operations Research, The Johns Hopkins University, Baltimore, Md. 21218; G. BENNINGTON and S. LUBORE, Members of the Technical Staff, The MITRE Corp., McLean, Va. 22101.*

A set of edges, D , is said to isolate a set of nodes, S , from an undirected graph if every chain between the nodes in S contains at least one edge from the set D . Further, if a cost, $c(e)$, is associated with the removal of edge e , then the determination of the minimum cost isolation may be formulated as a 0-1 integer linear program. The associated linear program is decomposed and the subproblems are solved utilizing the out-of-kilter algorithm. A branch and bound algorithm is used to obtain the desired integer solutions.

Computational results will be discussed and an alternative formulation as a special quadratic assignment problem will be given.

IIID.4 A Simplexes Decomposition Algorithm for Integer Linear Programming, *HAJIME ETO, Hitachi Central Research Laboratory, Kokubunji, Tokyo, Japan.*

The algorithm consists of:

1. Reducing the given problem in n -dimensional Euclidean space to a simpler one in $n-1$ dimensions. This is done by examining the intersection of the original convex polyhedron with the hyperplane specified by an integer-admissible value of the primary objective function.
2. Decomposing the resulting reduced convex polyhedron into simplexes according to a secondary objective function. (Hence, a multi-objective problem can be treated.) The decomposition is computationally feasible.
3. Finding an integer solution as a convex linear combination of extreme points of a simplex. This is done by just knowing if or not a system of n linear equations is solvable.

The first solution found is optimal.

IIID.5 An Improved Combinatorial Programming Algorithm for Zero-One Integer Programming, *JOHN F. PIERCE, Consultant (IBM) and Assistant Professor, MIT School of Management, Cambridge, Massachusetts 02139, and JEFFREY S. LASKY, MIT Dept. of Operations Research, Cambridge, Massachusetts 02139.*

A discussion of an improved algorithm for solving integer programming problems having zero-one variables and constraint coefficients. Such problems arise, for example, in dispatching delivery vehicles, designing switching circuits, retrieval of data from an information system, investment analysis, and so on. This improved algorithm resulted from the use of reduction and filtering mechanisms together with an improved search strategy. This algorithm solved a truck dispatching problem (1156 variables, 19 constraints) in 1/2 minute on an IBM 7094. A previous algorithm (published in *Management Science*, November 1968) did not solve this problem in 40 minutes.

IIIG.1 Technological Forecasting—What Effect Does It Have on Aerospace Planning? *PETER H. NEUKIRCH, Martin Marietta Corp., Denver, Colorado 80201.*

This paper will evaluate two questions. One, how can various technology forecasting techniques, available today, aid the aerospace planner in determining the advances that will shape the future space program? And secondly, what will be the pacing factor in the progress of the nation's space program—the advances in technology or socio, economic and political elements?

IVA.1 Current and Future Range Considerations, *MAJ. GEN. DAVID M. JONES, Commander, Air Force Eastern Test Range, Patrick Air Force Base, Florida 32925.*

This paper presents a perceptive inside-view of the Eastern Test Range's pioneering role in major systems testing and space operations at Cape Kennedy. Key events and causes introducing change in aerospace support are analyzed. Review is made of economic trade-offs in relation to configuration and performance requirements imposed by increasingly sophisticated test environments. Factors influencing management and technical interfaces between general-purpose range and unique range-user activities are isolated. A general forecast of further transitions in ground-based networks and global deployment of ship and airborne sensors as well as space launch support facilities is developed.

IVA.2 Para Wing Space Shuttle, *THEODORE W. KANACKE, Technical Manager, Advanced Landing System, Northrop Corporation, Ventura Division, Newbury Park, California.*

The Apollo, Gemini and Mercury spacecraft landed with ballistic parachutes in the ocean that forms an almost unlimited landing area. The next generation of spacecraft will land on land most likely with lifting parachutes such as the parafoil or para wing. This introduces the requirement for terminal guidance toward a suitable preselected, prepared or emergency landing area. The need and requirements for a descent and terminal landing pattern somewhat similar to aircraft or low performance gliders will be discussed as well as present thinking on re-entry accuracy, terminal guidance, para wing/spacecraft flight performance, landing pattern and required ground facilities.

IVA.3 Resource Allocation in Spaceflight Command and Control Networks, *PHILIP A. BARRETT, Manager, Advanced Command and Control Programs, Lockheed Missiles and Space Company, 1111 Lockheed Way, Sunnyvale, California 94088.*

This paper presents the latest developments in design of advanced control networks for military satellites. Particular stress is laid on new techniques for automatic conflict resolutions for network scheduling required by extremely high utilization of network resources. Automatic resource allocation is discussed, and the management tasks for satellite control networks are sized for 1970-1980 time frames. Consideration is given to the joint NASA/DOD use of future space-flight control facilities for the projected simultaneous population of 250 payloads in 120 satellites during the next decade. Stringent user requirements are presented with their effect on command and control system design.

IVA.4 Planning Space Activities in the 1970's, *KLAUSE P. HEISS, Mathematica, 1 Palmer Square, Princeton, New Jersey 08540; OSKAR MORGENSTERN, Princeton University, Princeton, New Jersey 08540.*

The pressing need for a rational framework of thought in the planning of future space activities raises the following main themes: a) the economic effects, direct and indirect, of the space program; b) the contribution which economic theory can make to the planning and organization of space programs; c) the financing of space activities: fiscal and budgetary considerations. The space effort, economically seen, is entirely a case of public investment of national resources. Therefore, it must answer the question as to what are its public benefits. Can they be properly defined and measured? Are they the most important benefits to which the resources can be directed?

IVB.2 Reclamations Water Challenges for the '70's, *FLOYD E. DOMINY, Commissioner, Bureau of Reclamation, Department of the Interior, Washington, D. C. 20240.*

Water needs of the 17 Western states will continue to expand during the next decade. Local service and ground water supplies are essentially fully utilized in many areas. This will be true of large regions within ten years. Supplemental water supplies will be necessary to permit continued economic growth. As a water resource development agency, the Bureau of Reclamation will continue to examine alternative means of providing supplemental water. In addition to conventional developments, the Bureau will intensify consideration of

such means as more efficient use of existing supplies, precipitation management, and de-salination methods. Quality of existing and supplemental supplies is a major concern.

IVB.3 Optimal Estuarine Water Quality Management, *SHISHIR K. MUKHERJEE, Bechtel Corporation, 50 Beale St., San Francisco, California 94119.*

In this paper, a multi-component model of water quality control in an estuary is developed. Given a prescribed water quality standard in an estuary, expressed as maximum allowable concentrations of multiple water quality constituents, this model obtains an optimal plan of effluent treatment by waste-producing agencies along with an optimal plan of effluent discharge in the estuary by minimizing the total cost of pollution abatement for the estuarine region.

A complete linear programming model is obtained by the inclusion of waste treatment activities and costs for all agencies in the Dispersion Model and is illustrated by examples.

IVB.4 An Algorithm for Irrigation Project Planning, *PETER ROGERS and DOUGLAS V. SMITH, Harvard University—Center for Population Studies, 22 Plympton Street, Cambridge, Massachusetts 02138.*

A linear programming model is formulated to aid in the planning of irrigation projects. The model is based on a water balance for the project area and focuses on the interactions of a surface water-groundwater system within the economic context of irrigation management. The program selects the tubewell, canal, and surface drainage capacities, the project size, and the cropping pattern. Monthly operation of the system is assumed to proceed subject to certain constraints on continuity at the river; capacity of the canals, tubewells, and drainage channels; mining of groundwater; crop water requirements; availability of land of different soil types; and permissible cropping patterns. A detailed example from East Pakistan is presented together with an exploration of the sensitivity of the solution to physical and socio-economic variables.

IVB.5 Management of Water Resources, *JOHN W. HUNG, McDonnell Douglas Astronautics, Huntington Beach, Calif. 92647.*

It is important for water resources management to evaluate quantity and quality of water resources both above and below the surface using a computer-based mathematical model to simulate the dynamic behavior of the ground water basin. Comprehensive geologic and hydrologic investigations provide the data, and a hybrid computer is used to develop and test the new model. The water basin is divided into rectangular sub-areas to account for the irregularity of the basin and the boundary value conditions. As many as 40 nodes can be simulated on one section of the analog computer without resorting to iteration or use of additional sections. Typical data is shown.

IVB.6 Water Resource Development for Denver Metropolitan Area, *R. E. WIEDEMANN, Chief of Water Resources, Denver Board of Water Commissioners, Denver, Colorado 80202.*

This paper presents an outline of problems related to providing an adequate water supply to support a large and expanding urban economy in a semi-arid climate. How these problems have been and are presently being handled in the Denver Metropolitan Area by an independent water agency without State or Federal assistance will be discussed. Specific items will include the acquisition and development of the limited water resources available and the excessive lead time required in such development, extreme system demands occasioned by climatic conditions, and financing methods.

IVC.1 The Global Atmospheric Research Program, *DOUGLAS K. LILLY, National Center for Atmospheric Research, Boulder, Colorado 80302.*

There is now good reason to believe in the possibility of a significant breakthrough in the heretofore slow progress of weather forecasting. The results of several theoretical studies

agree in the conclusion that the Earth's atmosphere is inherently predictable in significant detail by numerical solution of the governing equations, for periods of up to two weeks or a little more. Realization of this theoretical limit will require an order of magnitude enhancement of the world's meteorological observation capabilities, plus a coordinated international research effort to fill in the gaps in the mathematical formulation of the prediction equations.

IVC.2 Buoys in the Sky and Ocean, *JOHN E. MASTERSON, National Center for Atmospheric Research, Boulder, Colorado 80302.*

Direct global measurement of the basic variables of the atmosphere and ocean is fundamental to understanding the motions of the atmosphere and the associated weather. Small, non-extensible balloons that float at a fixed altitude or on a constant density surface in the atmosphere are excellent vehicles for the measurement of wind and temperature. To understand the energy exchange between the atmosphere and the ocean, measurements are necessary of temperature, pressure, and wind in the large oceanographic regions for which we presently have insufficient data. This requirement may be met by simple buoy platforms freely floating over large ocean areas.

IVC.3 Air, Weather, Climate and Man, *JOHN L. BUCKLEY, Technical Assistant, Office of Science and Technology, Executive Office of the President, Washington, D. C. 20500.*

In addition to the obvious effects of our actions on air quality, so evident in the evil-smelling air of a pulp mill town or the eye-burning smog of a Los Angeles, we now see effects on weather and climate. "Heat islands", ice fog in Alaska and, more recently increased precipitation in LaPorte, Indiana, have been discussed. Still more wide-ranging effects like acid rains, increased cirrus cloud cover (from contrails), and the "greenhouse" effect of carbon dioxide are now reported. Some of the efforts now under way to assure understanding of these phenomena and to control them as need be are discussed.

IVC.4 Weather Modification in the 1970's, *ARCHIE M. KAHAN, Chief, Office of Atmospheric Water Resources, Bureau of Reclamation, Denver, Colorado 80225.*

Since 20 years elapsed between the clearly demonstrated ability to dissipate supercooled stratus by cloud seeding and routine application to clearing supercooled fogs at a few of the busier airports, some restraint in predicting progress in beneficial weather modification in a mere 10 years seems justified. It is not too much to expect the benefits of both warm and cold fog dissipation to become routinely available during the 1970's, in addition to increased water supply for selected basins resulting from precipitation management. Hail suppression research should yield additional results suitable for beneficial application in the next 10 years. Severe storm abatement research appears to require much more time.

IVD.4 How to Use Security Analysis to Improve Portfolio Selection, *JACK L. TREYNOR Arthur D. Little, Inc., Cambridge, Mass., and FISCHER BLACK, Merrill, Lynch, Pierce, Fenner & Smith, Inc., 70 Pine Street, New York, N. Y. 10005.*

The Markowitz model is widely accepted as a statement of the basic principles of portfolio selection, but the model requires inputs which are not readily forthcoming from conventional security analysis. This paper shows how the inputs required by the portfolio selection process can be supplied by security analysis. It also develops heretofore unrecognized principles of portfolio balancing to derive optimal holdings of individual securities, as well as insights relating to optimal turnover rates and the optimal number of securities to hold. The model also has important implications for measurement of fund performance.

IVG.1 A Performer-Oriented Approach to Systems Quality, *RONALD LESSING, Operations Research Staff, U.S. Department of Health, Education, and Welfare, Baltimore, Maryland 21235.*

While traditional techniques of statistical quality control are capable of controlling quality level of an operating system, there is a need for a means of determining expected quality

level of a proposed system while it is being designed and a means of mathematically describing quality characteristics of existing systems for analysis and simulation. This paper contains a means of developing a quality control model of a general system in terms of error-producing and error-detecting characteristics of individual servers and machines that compose the system, so that the analyst can optimize number, type, and location of quality control components.

IVG.2 Choice of an Efficient Random Number Generator, *SALLY ANDERSON, Technical Staff, RAND Corporation, Santa Monica, California 90406.*

Although the techniques of random number generation is considered static, the choice of a generator for a new machine or compiler is still complex. This paper discusses the choice of a random number generator for SIMSCRIPT II, on the IBM 360, in the context of those properties desirable in a simulation; independent sequences, long period, low autocorrelation among the elements, uniformity and other well known properties. Candidate generators were tested to evaluate their performance in terms of the desired properties. Why a user should be concerned with the properties of a random number generation is also given attention.

IVG.3 An Alternative to Pseudo-Random Number Generators, *HERBERT BIXHCN, Technical Staff, BELLCOMM, Inc., Washington, D. C. 20024.*

Two methods are given for generating sets of vectors with properties which approximate those of a multi-variate normal distribution. The first method which applies to any number of dimensions forces the univariate marginal distribution of a set of points to approximate $N(0,1)$ with low correlation between components. The second method attempts to duplicate the property that a two dimensional normal random vector with identity covariance matrix have circles of constant density. These methods are being considered as replacements for pseudo-random number generators in certain types of Monte Carlo problems.

IVG.4 Estimating Sample Size in Simulation Experiments, *GEORGE S. FISHMAN, Technical Staff, RAND Corporation, Santa Monica, California 90406.*

This paper presents a method for computing sample size required to estimate the mean of a process in a digital simulation with a specified level of accuracy. The procedure described can be built into the simulation so that run length can be determined and executed without user intervention. The presentation includes a description of the underlying probability model, derivation of the variance of the sample mean, discussion of estimation procedures, flow charts showing how the sample size is computed and examples. Special problems like adjustment for bias and use of a minimum variance estimator of the mean also receive attention.

IVH.1 Portfolio Analysis in New Product Screening and Development, *PAUL F. HASE, The Pillsbury Co., 608 Second Ave. South, Minneapolis, Minnesota 55402.*

Products Department, it is not enough to screen new product ideas on their merits individually. Rather, they must be evaluated in relation to other active projects in the portfolio according to established group criteria; thus new ideas of lesser payoff may preempt others of greater potential unless other resources can be tapped or objectives (criteria) are overtly changed.

Because of the rapidity of project turnover in a New Products Department, models which deal with portfolio issues such as this one must be both complete and simple or they will never be used operationally. This paper will describe the set of models used at The Pillsbury Co.

IVH.3 Operations Research Marketing Applications, *HERBERT A. GOLDSTEIN, Lybrand, Ross Brothers and Montgomery, 60 Broad Street, New York, N.Y. 10004.*

This discussion will center on the use of Operations Research techniques in the

development of expected revenue values for territories, industries, or specific customers (present or potential).

Two specific areas of application of these techniques will be presented, namely, planning to enter potential markets and evaluating the performance of various segments of the marketing organization. Specific programs which have been performed in a variety of industries will be described.

The presentation will place particular emphasis on management expectations in this area and how the OR practitioner can best promote his services to his company's top management.

VA.1 Habitability of Manned Spacecraft, C. C. JOHNSON, Chief, Spacecraft Design Office, MSC, NASA.

Manned spacecraft weight, space, and energy budgets to date have allowed little beyond primitive living conditions for the crews. As missions become longer, the habitability aspect of the spacecraft must be afforded greater consideration. In this paper, the principal elements of habitability are identified and their bearing upon spacecraft design discussed.

VA.2 Prominence of Space Suits and Life Support Systems in Space, LARRY E. BELL, Chief, Extravehicular Equipment Development Branch, Crew Systems Division, MSC, NASA.

The original requirements for full pressure suits (space suits) was to provide a livable atmosphere in the event that the cockpit or cabin were to suddenly lose pressurization. The Manned Space Flight program has progressed in a careful step-by-step fashion and the use of extravehicular activities (EVA) have put a new requirement on the space suit. The current space suit provides the only atmosphere during EVA and has to offer minimum restriction to mobility providing thermal and hazard protection for longer and longer periods of time. The ultimate goal is to provide nude body mobility with adequate safety protection and structural capability to withstand the environments of space and lunar surface. To summarize, the space suit when attached to its portable life support system is now a spacecraft in lieu of a protective garment.

VA.3 An Approach to Selection and Training of Flight Crews for Extended Life Space Stations, W. P. STOCKING and R. L. CREASEY, Martin Marietta Corp., Denver, Colo.

Training for current space endeavors is deceptively easy in that little or no advance in the state-of-the-art has been required. This is not to say that effective training for highly advanced systems and functions requires "new" techniques. Rather, training should be efficient and effective regardless of mission complexity.

It is the objective of this paper to propose new considerations for crew selection and training caused by extended life space stations. New personnel categories for flight crews will include, in addition to the pilots, scientists and technicians. Some current astronaut requirements may be still imposed due to physical rigors still under investigation. However, requirements quite different and challenging will be presented. New problems such as updating training to resident crews so that proficiency is maintained is of prime importance.

VB.1 Irreversible Operations—A Network Analysis, J. P. SAKSENA and SANTOSH KUMAR, Directorate of Scientific Evaluation, Research and Development Organisation, New Delhi-12.

This paper gives a general description for a method of "imbedding" a system with irreversible operations into a network with nonsymmetric distance. The observation that adding constraints to a system makes the optimal solution worse, is made.

VB.2 An Algorithm for Universal Maximal Dynamic Flows in a Network, W. L. WILKINSON, The George Washington University Logistics Research Project, Washington, D. C. 20006.

This paper presents a modification to the Ford-Fulkerson algorithm for maximal dynamic flow in a time-weighted, capacitated network. The modification is mild, as conjectured by Gale, and produces a shipping schedule representing what has been termed the universal maximal dynamic flow. The universal feature is that in constructing a schedule for P

periods, this same schedule is maximal when truncated to p less than P periods. A numerical example is included which compares the temporally repeated and universal type solutions.

VB.3 Linear Integrated Circuit Design Using State-Space Concepts, R. W. NEWCOMB and P. DEWILDE, Dept. Electrical Engineering, Stanford Univ., 94305.

Recent theoretical state-space results have led to the practical design of linear integrated circuits. Here these results in terms of canonical sections will be discussed with extensions to more compact distributed structures and adjustable parameter circuits. Alternate methods will be compared with a discussion of investigations at Stanford in the area of microsystems.

VB.4 Linear Graphs as System Models, S. D. BEDROSIAN, University of Pennsylvania, Philadelphia, Pa. 19104.

A tutorial presentation will be made of the application of linear graphs (network topology) to system modeling. Particular emphasis will be given to the role of the mathematical tree and the determination of explicit formulas for the number of such trees in a variety of incomplete graphs. Following the development of the basic concepts, selected examples will be given to illustrate the versatility of this approach.

VB.5 Analysis and Comparison of Various Lower-Bounds on Schedule Times for the Solution of the Flow-shop Problem, SAID ASHOUR and M. N. QUARAIISHI, Department of Industrial Engineering, Kansas State University, Manhattan, Kansas 66502.

This paper is concerned with the solution of the flow shop problem in which a sequence of J jobs, to be processed on M machines, is to be determined such that the schedule time is minimized. A branch-and-bound technique was proposed by several investigators. This procedure involves generation of nodes that indicate partial sequences. A lower-bound on the schedule time is evaluated for each node in order to determine which node is to be explored. The number of explored nodes can be curtailed by a bounding process which is imbedded in the branch-and-bound algorithm. Five promising bounding procedures were proposed; however, their qualities were not investigated. The purpose of this paper is to analyze these lower-bounds mathematically and empirically.

VC.1 The LOFT Structure, JOHN M. HEDGEPEETH, Vice President, Astro Research Corporation, Santa Barbara, California 93103.

The LOFT concept is an apparently feasible approach for an orbiting large aperture paraboloidal radio telescope. It employs centrifugal forces to deploy and stiffen its mile diameter filamentary reflector. A 1/2 mile long central compression column is required to connect the base of the paraboloid to the feed at the focal point and to reset the axial tensile loads in the reflector and front stays. The results of detailed investigations of several aspects of the LOFT structure are reported. Included are trade off studies, geometrical concepts and a description of the characteristics of the various components of the configuration. Especial attention is given to the problems arising from the extremely low load levels in the deployed reflector and mast structures.

VC.2 Structural Design and Development of A Tactical Communications Satellite, PAUL W. BERNSTEIN, Senior Project Engineer, Hughes Aircraft Company, Space Systems Division, Los Angeles, California 90009.

The world's largest and most powerful communications satellite has recently been launched from Cape Kennedy. The 1600 pound satellite injected into a synchronous orbit by a Titan IIIC booster is as tall as a two story building and has a communications capability of 10,000 two-way telephone channels. Presented is criteria leading to its design, development, and subsequent launch. Unique subsystems such as structural solar panels and UHF antennas will be described. The effect of structural criteria on the design of hardware and structural tests imposed to verify design adequacy will be discussed.

VC.3 The Application of Flowgraphs to Elastomechanical Systems, *TORLEIV ENGER and CHUAN C. FENG, University of Colorado, Boulder, Colo.*

This paper presents the application of mathematical flowgraphs to elastomechanical systems. The oriented linear flowgraph combines the mathematical formulation and solution into a single process. The flowgraph is a topological network which represents the interrelations among a number of variables. The solution of a flowgraph can be obtained by standard reduction techniques or by a topological formula developed by Mason. This salient property attracts its application in the design process.

The paper includes two types of physical applications. A frequency flowgraph can be formulated directly by inspection of the system and yields the eigenvalues and eigenvectors in vibration analysis.

VC.4 Large Space Erectable Structures, *DESMOND H. VAUGHAN, Advanced Structures Design Engineer, General Dynamics Convair Division, San Diego, California.*

Payloads boosted into space thus far have been modest in size. In establishing manned lunar bases structures will be needed both for shelters and communications linkage. This paper presents a unique mechanical structure concept which permits large rigid structures to be deployed from very small packages. NASA contracts have in part supported three years applications study of a concept for large space antennas.

VC.5 Reusable Lifting Center-Body Launch Vehicle Concept for Pressure Fed Engines, *HANS F. WUENSCHER, Assistant Director, Advanced Projects, Manufacturing & Engineering Laboratory, MSFC, NASA, Huntsville, Alabama.*

A low cost lifting center-body recoverable booster concept is described where the intersecting pressure vessel or multi-cell configuration is utilized for structural optimization of the high pressure requirement. At the same time the multi-cell mode is used for shaping the tanks to a lifting body configuration serving the fly back and landing capability. The reentry stabilization and deceleration are provided by dive brakes. Skin temperatures over the first stage booster surfaces are low enough to permit the use of unprotected aluminum as the basic tank material. The conceptual layout is tailored to a 3 million lb. thrust class booster system.

VD.1 Dynamic Programming and Chemical Engineering, *DOUGLAS WILDE, Department of Chemical Engineering, Stanford University, Stanford, California 94305.*

Dynamic programming has seen limited application in the chemical industry. The structures of chemical processes include recycle loops and branches which prevent the direct application of serial dynamic programming procedures. However, modifications have been developed which extend serial methods to more general structures. While not always computationally practical, these "functional diagramming" methods indicate effective ways of breaking large problems down into small ones. This more general "partial optimization" approach will be illustrated with graphical examples.

VD.2 Dynamic Programming Optimization of Water Resources, *W. L. MEIER, JR., Dept. of Industrial Engineering, Texas A and M University, College Station, Texas 77843.*

To combat the rapidly developing water shortages in the U.S., massive projects are being proposed to redistribute water resources. This paper describes ways in which dynamic programming can be used in the planning of large water resource projects. The use of dynamic programming in the planning and design of reservoirs, aqueducts, and waste treatment facilities is illustrated. Projects for future use of dynamic programming in water resource analyses are discussed.

VD.3 A Dynamic Programming Model for Optimal Gift Allocation in Estate Planning, *HERBERT L. STONE, Dept. of Operations Research and Statistics, California State College, Long Beach, Calif. 90801.*

An optimal gift policy is defined as a sequence of annual gift proportions which will

maximize the return which is expressed as a scalar function. The current relevant information at stage i is described by a two dimensional state vector which lies within some region of the state space. A transformation of the state variables results in a policy which is a selection of n transformations yielding successive states. The principal of optimality is then used to maximize the desired objective function.

VF.1 Modeling the Community Health Service System, *ARNOLD PACKER, Research Triangle Institute, Research Triangle Park, N. C. 27709.*

This paper describes part of the research performed to investigate the feasibility of a simulation model of the community health service system. The tasks include: describing the elements and relationships of the total system; identifying the parameters by which the effectiveness of the system can be measured so that concepts of cost-effectiveness can be applied, identifying subsystems which can be profitably modeled; preparing a simulation model for a selected subsystem (Maternal and Child Care was selected, the results are reported in the following paper), recommending methods for incorporation of models of additional subsystems into the framework of the total system.

VF.2 The Maternal and Infant Care Simulation Model, *F. D. KENNEDY, Research Triangle Institute, Research Triangle Park, N. C. 27709.*

This paper describes a simulation model of a maternal and infant care project conducted in three North Carolina counties. Each case is followed from detection through delivery and the first year of the child's life. Various forms of assistance are given to these cases including: a) consultant service for high-risk cases of pregnancy, b) hospitalization for complicated cases of pregnancy, c) fees for the care of the pregnant woman and delivery of the high-risk patient, and d) transportation for these patients. The model is written in SIMSCRIPT and requires approximately four minutes run time to simulate five years operation for one clinic with an average yearly caseload of 300 mothers and 200 infants. Results of model verification are presented and potential uses of the model in the health planning operation are discussed.

VF.3 A Generalized Model for Planning Shared Health Services, *JOHN R. FREEMAN and MIGUEL F. SALDIVAR, Health Systems Research Division, University of Florida, Gainesville, Florida 32601.*

One of the recommendations of the Advisory Committee on Hospital Effectiveness, appointed by the Secretary of HEW, was that individual health institutions examine the opportunities to achieve improvement and economy through shared services. This paper presents a generalized cost model for application in decision situations involving the sharing, by two or more health institutions, of certain supportive or ancillary services, such as laboratory, laundry, food, housekeeping, purchasing, etc. The model is based primarily upon the influence of magnitude and variability of demands and service levels upon unit size, with consideration given to economics of scale, correlated demands, and transfer costs.

VF.4 An Application of Operations Research Techniques in the Social Security Disability Insurance Program, *FRANCIS C. J. ICHNIOWSKI, U.S. Public Health Service, 9000 Rockville Pike, Bethesda, Maryland 20014, and G. THEODORE SAFFRAN, Social Security Administration, Baltimore, Maryland 21203.*

The Operations Research Staff of the Social Security Administration performed an in-depth analysis of the Disability Insurance Program. The objective of the study was to analyze the disability claims process placing emphasis in the following areas: examine workflow patterns; improve the quality of output; gather information on arrival and dispatch patterns; list claimant characteristics and volumes of the types of cases; and compile processing, queue, and elapsed time characteristics of the workload. The study was developed across four phases ranging from orientation through data collection, analysis and simulation.

The research document being submitted described eight separate data collection programs relating some of the problem areas discovered.

VG.1 The Quantity Versus The Quality of The Data Used in The Derivation of A Cost Estimating Relationship, MORRIS J. ZUSMAN, *Institute for Defense Analysis, Washington, D. C. 22202.*

One of the most important, time consuming, and expensive steps necessary in the development of a cost model is the collection and analysis of data that will be used to derive the model's cost estimating relationships. Trade-offs on how a cost analyst might best allocate his time between collecting data on additional programs and analyzing in further detail the data already in his possession are presented using as a measure of the cost analyst's productivity, the reduction in the confidence bandwidth that might be drawn about the cost estimate.

VG.2 Automation of Launch Vehicle Adaptive Costs in Support of Long Range Space Planning, ROBERT E. DROWNS, *Design Specialist, General Dynamics/Convair, San Diego, California 92112.*

Long range planning costs which are used for the selection of launch vehicles must be based upon the anticipated usage of the launch vehicle. Concurrently, the expected usage of a launch vehicle is based upon its cost and capability. This paper presents the adaptive costing techniques developed in support of launch vehicles long range planning.

VG.3 An Extension of the Theory of Learning Curves, DONALD T. BARSKY, *Associate Professor of Accounting, Temple University, Philadelphia, Pa. 19122.*

An important approach to forecasting unit cost over time has been the development, application, and acceptance of the concept of learning or improvement curves. It is hypothesized that, *ceteris paribus*, unit costs decrease as economies are realized from repetitive production.

Current methodology relates future unit costs to the first unit cost. This analysis does not, however, permit adjustment for engineering change orders which either increases or decreases the original unit cost as a result of configuration changes. A model is proposed here to measure the total learning savings on the originally designed unit and subsequent positive and negative change orders.

VG.4 Macrobehavior of RDTE Estimates and Costs, HORACE SCHOW II, and W. J. TROPF, *Systems and Cost Analysis Division, Headquarters, U.S. Army Materiel Command, Washington, D. C. 20315.*

Competent management is dependent upon adequate records of past performance and experience. In the research-development-test-evaluation (RDTE) area not only must the actual costs be recorded but also the estimates. A standardized presentation format of RDTE cost estimating and performance should exist. It is the purpose of this report to (1) to present a standard graphical format on which the time-dependent RDTE estimates and actual costs can be displayed in a normalized manner; (2) to derive a mathematical expression, called the Efficacy rating, to describe, not judge, the estimative process; and (3) to give several case examples.

VH.1 Logistics Aspects of Urban Living, JAMES L. CARPENTER, JR., *Director, Logistics Support, Aerospace Group Headquarters, Martin Marietta Corporation, Friendship International Airport, Md. 21240, and CHARLES J. INSLEY, Sr. Logistics Engineer, Martin Marietta Corporation, Orlando, Fla.*

Population growth and the deepening urbanization of our nation are creating a host of new logistics problems. These promise to become even more complex in the next decade. Many temporary solutions to communications, transportation, and people service requirements are being provided on the basis of intuition rather than scientific analysis. Community planning lacks the tools routinely used by the military or industrial logistician. In this paper the authors will demonstrate how the logistician's tools can be the key to more effective community planning.

- VH.2** An Efficient Algorithm for Optimizing the Geographical Structure of a Warehouse System, *NICODEMO A. CICCIA, Manager, Computer Software Department, MELVIN H. BLITZ, Manager, Information Systems Department, GEORGE E. O'ROURKE, Staff of the Director, Applied Research Laboratory, Sylva Electronics Systems, 40 Sylvan Road, Waltham, Mass. 02154.*

This paper describes a system for determining warehouse configuration to minimize transportation and warehousing costs. The system involves a product with 125 local markets, two factories manufacturing different items in the product line, three existing warehouse locations, 12 candidate locations for additional warehouses, and freight rates and delivery times which are a function of point-to-point shipment quantities. The novel aspect of the solution technique is the use of the Gray code to generate the order in which warehouse configurations are examined to determine the optimum pairing of markets and warehouses.

- VH.3** An Experiment in the Application of Systems Analysis to Innovational Program Planning in Education, *MARTIN HERSHKOWITZ and SEYMOUR I. FINKEL, Vitro Laboratories, West Orange, New Jersey 07052.*

All programs to improve the quality of education view effectiveness as fundamental to project design; few, if any, are able to predict the effectiveness of a design in a formal, verifiable sense. The experiment described herein concerns the development of a mathematical model of an elementary/secondary school educational system as a tool for investigation and for prediction. In an attempt to apply the model it was discovered that the availability of data was subject to the capriciousness of economic and political considerations. Nevertheless, the model indicates the direction for needed research in educational systems design and innovational program evaluation.

- VH.4** Systems and Cost Effectiveness Analyses of the Logistics/Resupply of Manned Space Stations, *DANN MANN and PAUL McKOWEN, The Martin Marietta Corporation, Denver, Colorado 80201.*

This paper presents results of a systematic variation of parameters affecting the logistics/resupply process. Program costs and logistics are estimated as a function of space station requirements and the Titan and Saturn IB launch vehicles and derivatives thereof. The analysis combined deterministic and probabilistic approaches; computer programs were developed for each phase and are described herein.

- VJ.1** General Guidelines for Thermal Design and Analysis of Orbiting Telescopes, *M. COYLE, NASA Goddard Space Flight Center, Glenn Dale Road, Greenbelt, Md. 20770; D. ALMGREN and D. NATHANSON, Arthur D. Little, Inc., Acorn Park, Cambridge, Mass. 02140.*

This paper deals with the Analytical and Practical Aspects of the Thermal Design and Analysis of Orbiting Telescopes. The authors have been involved in the Thermal Design, Analyses and Testing of the OAO Experiments and will report on several aspects of this work. There will be a discussion of the effect on the interior radiation interchange due to the curved specularly reflecting primary mirror and due to the L/D ratio of the telescope tube. The thermal problems associated with interfacing to a parent spacecraft and with simulating orbital condition in a Thermal Vacuum Test with Optical Instruments will also be discussed. The paper concludes with conceptual thermal designs for future experiments.

- VJ.2** Thermal Control of the Apollo Telescope Mount, *GEORGE D. HOPSON, R-P & VE-PT, Marshall Space Flight Center, Huntsville, Ala. 35812.*

The Apollo Telescope Mount (ATM) is a manned, earth orbiting solar observatory which uses several sophisticated telescopes to record solar phenomena in the x-ray, ultraviolet, white light, and hydrogen alpha spectra. Because of stringent pointing stability require-

ments, close thermal control is required to prevent excessive thermal distortions. The telescopes use electrical heaters, insulation, and thermal control coatings, and are radiatively coupled to a liquid cooled sink. In addition, the pointing and control, power, and telemetry systems include over 100 major electronic components which are thermally controlled using heaters, insulation and thermal coatings. This paper gives details of ATM thermal analyses, design and testing.

VJ.3 Thermal Design for the OSO-F University of Minnesota Experiment, *RICHARD R. ANDERSON, Ball Brothers Research Corporation, P.O. Box 191, Boulder, Colorado 80302.*

The OSO spacecraft provides a mean orbital temperature environment of approximately 17 degree Centigrade for wheel mounted experiments. This environment was not compatible with the Zodiacal Light Monitor experiment. The photomultiplier tubes used in this experiment are too sensitive if operated at a temperature lower than the mean spacecraft temperature. BBRC was asked to modify the spacecraft thermal design such that the experiment would operate at a mean temperature of zero degree Centigrade and still maintain other spacecraft temperatures within the design limits.

The design modifications are described and the results of the thermal analysis are compared with thermal vacuum chamber test results and with flight temperature measurements.

VJ.4 Thermal Control of Four Apollo Telescope Mount Instruments, *D. E. REGENBRECHT, Ball Brothers Research Corporation, P.O. Box 191, Boulder, Colorado 80302.*

The Apollo Telescope Mount (ATM) carries eight telescopic instruments for solar observations. They consist of one instrument for the High Altitude Observatory (HAO), one for the Harvard College Observatory (HCO) and two for the Naval Research Laboratories (NRL). Thermal distortion effects on these four instruments require thermal control as close as plus or minus one degree Fahrenheit in level and gradients as small as one tenth of a degree Fahrenheit in 15 minutes. Because all instruments are not as thermally sensitive, two Thermal Control Systems (TCS) have been designed. Both systems use stand-off heater panels that are thermally coupled to the instruments primarily by radiation. A controlled environment is therefore provided for the instruments rather than direct heating, and a simpler TCS results. The design, analysis and test results are described.

VIB.1 Wildlife Resources Management and the Human Population, *HARRY R. WOODWARD, Director, Colorado Division of Game, Fish and Parks, 6060 Broadway, Denver, Colo. 80216.*

Population predictions from the demographer's statistical crystal ball forewarn of increasing problems relating to human needs for food and space. Meeting social requirements also is becoming more difficult, including the provision of recreational opportunities. The use and disturbance of land areas by humans is largely incompatible with wildlife production. Concern is expressed that man may eventually drive wild game from the face of the Earth.

To meet the demands for wildlife and outdoor recreational resources, adverse effects of man's activities on the environment must be remedied. As a first step, concentration of human populations and the majority of their activities in areas with low wildlife production potential must be given greater attention.

VIB.2 Recreation in the Year 2,000, *MAURICE D. ARNOLD, Regional Director, Bureau of Outdoor Recreation, State of Colorado, Bldg. 41, Denver Federal Center, Denver, Colo. 80225.*

Predicting tomorrow's events is always risky. Projecting into the '70's is extended in this presentation to "Recreation in the Year 2,000." A two-prong approach is taken to challenge the audience to think about the potentials in this field.

Based on a spiraling technology and economy, the future activities of our citizens and their recreational pursuits stretch the imagination. A sail boat trip around the moon propelled by solar energy could provide a challenge for next generations' teenagers. Miniaturization of recreational pursuits may be necessitated by the limitations of a home beneath the sea. Active types of recreation will not depend upon surface transportation for mobility. Passive recreation may include 3-D TV with a sight, sound, smell and touch.

VIC.1 Flight Observation and Prediction of the Performance of Satellite Thermal Control Surfaces, *ROGER K. WEDEL, Lockheed Missiles and Space Co., Sunnyvale Calif., and MANUEL L. MORRIS, Lockheed Burbank.*

The nominal optical properties of thermal control surfaces used for the passive temperature control of satellites and the changes in these properties when subjected to the environmental conditions of outer space have been determined from flight data.

Equipment and structural flight data temperatures were obtained from two identical satellites for periods of approximately one year over a wide range of solar incidence angles. The performance of five thermal control surfaces (two white paints, one aluminum paint, one second surface mirror, and one glass covered silicone solar cell) were determined by matching the flight data against temperature predictions from a thermal mathematical model of the satellite.

Expected nominal properties were obtained for all surfaces but the second surface mirrors. After a period of time large, unexpected changes in optical properties were observed for the three painted surfaces. No changes were observed for the glass covered silicone solar cells and the second surface mirrors.

VIC.2 A New Concept in Cryogenic Insulation for Spacecraft Propulsion Systems, *PAUL STEPHENS, Design Specialist, Convair Division of General Dynamics, 5001 Kearny Villa Rd., P.O. Box 1128, San Diego, California 92112.*

Cryogenic propellant systems are not currently being utilized for spacecraft propulsion for three primary reasons (1) tank/insulation/structural concepts being considered are relatively heavy, (2) the insulations are costly and, (3) the insulations are complex and therefore of reduced reliability when compared to storable propellant propulsion systems.

A tank/insulation/structural concept was developed which is light weight, has a low cost, simple and has inherently high reliability. The system was identified thru an evolutionary process which will be described in the complete paper. A ten foot diameter tank has been delivered with the insulation to the Air Force for testing at the Air Force Rocket Propulsion Laboratory, for a cost of approximately \$100,000. The paper will describe the design and thermodynamic characteristics of the concept.

To the author's knowledge this concept has not been identified or described in previous publications.

VIC.3 A Laboratory Method for the Determination of Effective Emittance of Spacecraft Thermal Control Louvers, *ANGELO J. BOSCIA, Member Technical Staff, Test and Evaluation Section, Fairchild Hiller Corporation, Germantown, Md. 20767.*

The recent extensive use of thermal control louvers for spacecraft applications has developed a need for the establishment of an accurate laboratory test method for the determination of effective emittance. A unique method is presented; it employs conventional laboratory facilities and instrumentation, coupled with guard heater techniques. The method is designed to minimize, or eliminate, undesirable heat losses which will assure accuracies within the limits of the instrumentation utilized. Various thermal levels were selected in order to actuate the louver blades to their fully opened, fully closed and intermediate positions. The laboratory test data is also presented and demonstrates typical characteristic effective emittance variations with respect to blade position.

VID.1 Cybernetics Viewed as a Meta-Language for Unifying Science and Science Education, *GEORGE J. KLIR, Assoc. Prof. of Electrical Engineering, Fairleigh Dickinson University, Teaneck, New Jersey 07666.*

Cybernetics viewed as an interdisciplinary meta-language with which to teach several skills, concepts and processes simultaneously more effectively, quickly and economically than any one of them alone.

VID.2 Systems Analysis as Applied to Educational Technology, *ROBERT E. De KIEFFER, University of Colorado, Boulder, Colorado 80302.*

The story of a systems analysis approach to the problems of educational telecommunication for the State of Colorado is presented.

VID.3 Systems Approach to the Utilization of Educational Resources, *BELA H. BANATHY, Director, East Europe-Middle East Division, Defense Language Institute, Monterey, California 93940.*

The use of systems planning in designing and implementing strategies for the utilization of resources is described.

VIF.1 Systems Analysis in Hospital Extended Care Planning, *M. E. COHEN, Systems Engineer, General Electric Company, Re-entry Systems, P.O. Box 7722, Philadelphia, Pa. 19101.*

This paper describes the application of the techniques of Systems Analysis in the planning of an extended care facility. Methodologies are developed to establish patient care profiles for various diagnosis categories. The profiles describe the type, amount, and cost of health services required as a function of diagnosis category hospital stay time. These profiles permit a determination of the expected transfer dates of patients to the extended care facility. Bed, staff, and special services requirements of each patient category in the facility are developed. A methodology is also outlined for establishing the optimum system specification for meeting these requirements.

VIF.2 Medical Information Systems, BRADNER L. HISEY, Manager, Hospital Information Systems, Lockheed Missiles and Space Co., Sunnyvale, California 94088.

Information processing—the collection, retrieval, and communication of data—is central to medical practice. The expansion of medical knowledge and the rising demand for patient care are taxing the medical profession to the limit of its information processing capabilities.

During the past five years Lockheed has completed detail analysis of hospital information processing. The work has led to the design of a comprehensive medical information system that will bring computer-aided information processing technology into the routine service of physician, nurse, administrator, and patient in the interest of economy of physician time and augmentation of his capabilities, more effective hospital management and improved patient care.

VIF.3 The Delivery of Health Care: A Network Flow Problem, ROBERT H. HINKLE, U.S. Naval Weapons Laboratory, Dahlgren, Virginia 22448, and ANTHONY M. JEZIOR, School of Industrial Engineering, Georgia Institute of Technology, Atlanta, Georgia 30332.

The next major government-financed attack on health problems will apparently give emphasis to preventive medicine. The program, called "preventicare" is aimed at establishing a network of neighborhood testing centers. Obviously, the effect of this program in providing an increased level of health care to the population will be minimized unless those persons who are found to require clinical treatment can gain timely access to the necessary treatment facilities. This paper attempts to treat the examining centers, the out-patient clinics, and the hospital facilities as a total system for the delivery of health care.

VIG.1 Optimization Techniques and the Assignment of Computer System Components, G. R. SHERMAN, Director, University Computing Center, University of Tennessee, Knoxville, Tenn. 37916.

Investigators working in areas of management science and related fields have developed several useful approaches to the general problem of functional optimization. Optimizing the allocation of resources in large and complex computer systems is currently of major interest to computer scientists. Several of the methods well-known in operations research can be applied to the problems arising in computer software design, but with varying degrees of practicality. This application of O.R. technology is discussed, and relationships to the problems in modern computation are pointed out. Theoretical developments, case histories, and experimental data are drawn upon in the presentation.

VIG.2 Branch and Bound Methods for Optimizing, C. M. SHETTY, Georgia Institute of Technology, Atlanta, Georgia 30332, and T. D. CASH, JR., Burlington Management Services Co., Greensboro, N. C. 37402.

This paper deals with the structure of the general Branch and Bound method to solve a class of optimum allocation problems. The presentation follows closely that of Lawler and Wood. Sufficient conditions are specified which will insure convergence of a Branch and Bound algorithm in a finite number of steps. The two approaches adopted in Branch and Bound methods (as exemplified by Eastman's algorithm for the Traveling Salesman problem, and Balas' additive algorithm for 0-1 variables) will be presented in terms of this structure. Certain optimization problems which can readily be attacked using the above structure are discussed.

VIG.3 On Modeling the Resource Allocation and Control Problem, ROBERT N. BRASWELL, Industrial and Systems Engineering Department, University of Florida, Gainesville, Fla., 32601.

Based on the supposition that task progress is the growth of conceptual developments in a work process, a system of mathematical models is developed. The integration of these models with the computer form a composite algorithm to put decision-making for the

allocation and control of resources on a quantitative basis. A task operating characteristic (TOC) curve is developed and used to predict and analyze task progress and serve as the basis for the conception and development of a resource operating characteristic (ROC) curve, a task progress (TP) model, a resource depletion (RD) model and an optimal path (OP) model. The final result circumvents existing rules-of-thumb, subjective and non-computerized decision-making methodologies, and validates the feasibility of quantitatively describing the resource allocation and control problem.

VIG.4 Optimal Allocation of Missiles Against Area and Point Defenses, *FREDERIC A. MIERCORT and RICHARD M. SOLAND, Research Analysis Corporation, McLean, Virginia 22101.*

The problem considered is that of allocating a given number of missiles against area and point defenses and the cities protected by these defenses so as to maximize the total damage done to the cities. An integer nonlinear programming formulation of the problem is developed and a branch-and-bound algorithm for its solution is offered. Computational considerations are discussed and numerical results are given.

VIG.5 Determination of the Optimal Number of Units, Operators and Repairmen, *BARRY BOECKER, General Dynamics, Fort Worth Division; WILLIAM G. LESSO, Associate Professor, Operations Research Group, Department of Mechanical Engineering, University of Texas 78712.*

This paper presents a method for determining the optimal number of units, operators and repairmen for a system. The units making up the system may be machines, vehicles, aircraft, etc. The measure of effectiveness is expressed as a quadratic function having the characteristic of decreasing returns as more units are added. This measure could be either revenue or any other measure of effectiveness such as probability of success or reliability. The other major factors are a mean time to failure for the units, and mean time to repair for the repairman. For a given configuration, (i.e. number units, operators, repairman) a sub model using queuing theory is used to evaluate the objective function. To determine the optimal configuration, a Heuristic is used that gives a close approximation from which a very simple search technique quickly reached the optimum.

VIG.6 PACE, An Adaptive Real Time Allocation System, *WILLIAM H. EVERS and SUNDER S. THAKUR, IBM Corporate Headquarters, New York.*

The problem of real time allocation over a network of multi-skill servicemen to a service work load is considered. A general approach to real time allocation is presented which appears applicable in many areas. The formulation for this problem is initially considered as one of minimizing total travel cost over a finite horizon subject to numerous constraints such as overtime, response time and service capability representing the desired servicing characteristics.

The mathematical problem is then reformulated as a chance constrained programming problem involving both the original costs and the costs of infeasibility in the objective function. A real time adaptive control procedure is utilized to minimize the new objective function while ensuring that the prespecified probability of infeasibilities are met. An application to a nationwide servicing network is presented.

VIG.7 Allocation of Investigative Effort in Multi-Project Decision Problems, *Y. S. CHANG, Boston University, Boston, Mass.*

Given the constraints of manpower resource at the Internal Revenue Service, how much investigative effort is to be allocated to verify the accuracy of individual tax return? A pragmatic rule commonly used in practice is that of ABC Method in which Class A projects of high investment requirement or potential payoff would be thoroughly investigated while C Class projects would receive only cursory evaluation.

An ideal allocation model would match the marginal benefit of investigative effort to the marginal cost. The concept of estimation deviation is suggested as a basis for allocation in this paper.

VIH.1 In-Flight Maintenance of Space Station and Spacecraft, D. A. BARNES, Branch Chief, Advanced Systems and Technology Logistics Support, McDonnell Douglas Astronautics, Western Division, Santa Monica, California 90406.

There has been considerable discussion of whether or not in-flight maintenance is a valid requirement. A review of past experience clearly shows that human error and equipment failure are ever-present, and have a definite effect on mission success; therefore, the major issue is not *whether* an in-flight maintenance capability should be developed, but rather *how* this capability can be developed in terms of technical and economic feasibility. Current and future space maintenance requirements are presented, showing the dynamic relationship of these requirements with reliability, maintainability, equipment design and human factors criteria, together with the ultimate effect on mission success.

VIH.2 A New Approach to Logistics Management, CLIFFORD J. HALL, Manager, Operational Support Office, Apollo Applications Program Office, Manned Space Center, Houston, Texas 77058; HILAND GARDNER, General Electric, Apollo Support Division, Houston, Texas 77058.

The presentation is based on the philosophy and approach used to develop the Manned Spacecraft Center (MSC) Apollo Applications Program (AAP) Logistics Requirements Document MSC-KT-D-68-3. The concept of program management-by-exception with the Government specifying program requirements and delegating maximum responsibility to contractors for development and performance was utilized. The uniqueness of this philosophy is that the Contractor's responsibilities are specified in the Government requirements document. In summary, this presentation provides an insight to the concepts for management and control of the logistics program with limited funding, minimum manpower, and maximum use of existing resources.

VIIA.1 Lunar Surface Exploration, O. LYLE TIFFANY, Chief Scientist, Bendix Aerospace, Ann Arbor, Mich.

This paper will review the efforts which have been applied to the problem of achieving an understanding of lunar geology by surface exploration. Program studies and hardware development will be reviewed including both survey vehicles and sensors. It will show the feasibility of accomplishing data acquisition both within the Apollo program and beyond. An examination of present program efforts will be included.

VIIA.2 Extraterrestrial Construction, BRUCE HALL, Chief Scientist of Extraterrestrial Research Agency, Office of the Chief of Engineers, and HARRY N. LOWE, Chief of Extraterrestrial Research Agency, U.S. Army.

Advanced lunar and other extraterrestrial exploration present a unique requirement for structures related to the particular locale of the exploration. In this paper the authors address the program required to establish the design and to construct a prototype of an extraterrestrial structure. An important application of a prototype of the proposed structural devices would be for human factors evaluation and crew training in deployment and use.

The suggested program approaches would be typical of those prerequisites to the establishment of a comprehensive extraterrestrial surface exploration program.

VIIA.3 The Challenge of Lunar Exploration, DONALD U. WISE, Deputy Director of Apollo Lunar Explorations Operations, NASA, Washington, D. C.

Exploration of the Moon is now recognized as an achievable goal. Plans for such exploration have been evolving over the past years as an integration and iteration of the

efforts of many individual scientists, engineers and corporate and government agencies. The current status of these plans will be presented.

Discussions will include plans for maximizing the technical yield of present programs as well as projections of possible future approaches to broader investigations than are within the capability of presently available technology or hardware programs.

VIIA.4 Lunar Orbital Exploration, *CARL L. KOBER, Program Scientist, Manned Space Systems, Martin Marietta Corp., Denver, Colo.*

Lunar orbital exploration is contrasted to lunar surface exploration in respect to emphasis of large scale lunar features exploration. They are survey of lunar mass distributions, thermal anomalies in rilles, crater bottoms, active or dormant volcanoes; measurement of the weak lunar magnetic field excited by solar wind; large scale geological mapping of the moon by gamma-ray backscatter and infrared measurements. Such measurements will complement the detailed, but site restricted lunar surface exploration program to yield answers to the problem of how the moon was formed.

The instrumentation to carry out these missions contains an array of various sensors, such as; photographic cameras; infrared sensor, microwave imagers, active soil penetrating microwave sounders; ultraviolet, X-ray and gamma-ray sensors and means to determine gravity anomalies.

Apollo spacecraft will be the vehicle for lunar orbital exploration, although payload capability will limit the program to a $\pm 14^\circ$ latitude equatorial belt. It will be shown that this belt contains all the interesting features to be surveyed, such as the Marius Hills, Mare Orientale, the Apennines and Hyginus Rille, low domes and others offering a sufficient cross-section to collect representative data for the above enumerated goals.

A discussion of spacecraft instrumentation, orbit selection, payload and data link allocation shows the feasibility of lunar orbital exploration within the frame work of the Apollo program.

VIIB.1 Management of Fuel Resources, *RUSSELL S. CAMERON, Cameron and Jones, Inc., Denver, Colorado 80222.*

This paper will deal with Earth's inventory of fuel resources, trends in the patterns of usage, and finally their management to man's benefit. Owing to their dominant role in the present era fossil fuels will be examined in depth and as well as can be postulated, atomic energy will be explored.

Since government influence in the form of regulation, taxation, research support, etc. is such a strong factor in the selection and use of fuel resources, some of its effects also will be noted.

Finally, the effectiveness of our present system of fuel resource management will be appraised.

VIIB.2 Management of Non-Fuel Resources, *ALVIN KAUFMAN, Chief, Mineral Economics Group, Bureau of Land Management, U.S. Department of the Interior, Washington, D. C. 20006.*

This paper will first discuss some of the challenges that face the non-fuel mineral industries in the 1970's, such as rising demand, environmental controls, pressure from substitute materials, etc. The planning mechanism in the United States will then be explored. This will include a discussion of the indirect nature of such planning. Included will be use of such items as taxation, subsidies, etc., to accomplish the desired end. Minerals on the public lands will then be used as an example of such planning.

VIIB.3 Planning to Meet the Needs for Mineral Resources, CHARLES M. MOTTLEY, *The Pennsylvania State University, Office of the Vice President for Planning, University Park, Pa. 16802.*

Over the next thirty years the world-wide consumption of minerals to satisfy the materials needs of exploding populations and their rising living standards will be huge. Our mineral industries are going overseas more and more to obtain supplies of key materials notwithstanding the attendant hazards of losing control of their sources. In spite of the foreseeable demands, mineral science and technology are lagging; mineral education is declining; and our mineral policies are either nonexistent or have a short-range, expedient thrust.

The paper discusses the necessity for a new approach to meet the challenge. It is suggested that competent strategic planning must be instituted as the basis for effective mineral resource management.

VIIB.4 Planning for Construction Minerals in the Urban Environment, JAMES R. DUNN, *Professor of Economic Geology, and WILLIAM A. WALLACE, Associate Professor of Management and Director, Urban Environmental Studies, Rensselaer Polytechnic Institute.*

Urban areas have the difficult problem of intelligently zoning for optimum aesthetic and growth values. The complexity of land use planning for metropolitan areas is compounded when the land is underlain by a mineral resource. Equating the present and future potential value of land as a source of raw materials against a competing use must consider such factors as the non-renewable nature of mineral resources, population trends, transportation, production and labor costs, and possible rehabilitation of cities.

This paper presents a discussion of a computer simulation model that will aid in the planning for non-renewable mineral resources in urban-suburban environs.

VIIC.2 Minimization of Training Cost and Quantity of Multi-Skilled Personnel when Requirements are Uncertain, KENNETH W. HAYNAM, *U.S. Army Behavioral Science Research Laboratory, Dept. of the Army, Room 239, The Commonwealth Bldg., 1320 Wilson Blvd., Arlington, Va. 22209.*

An algorithm is developed which minimizes both the quantity of personnel and training costs necessary to meet skill requirements which are uncertain. The present algorithm is applicable when personnel may be given training in one or more skills and the requirements are for single skills.

Given n contingencies in terms of the required number of men in each of m skills, the algorithm calculates the optimum mix of personnel with multiple and single skills to satisfy skill requirements completely no matter which contingency is realized. The solution algorithm was developed to calculate the optimum training composition of a contingency force of Army aviators.

VIIC.3 On the Adjustment of Indirect Fires by Use of Quasilinearization, *W. D. O'NEIL and J. R. HOLDSWORTH, Litton Industries, Advanced Marine Technology Division, 9920 Jefferson Blvd., Culver City, Calif. 90230.*

A method is presented for the adjustment of artillery fires on the basis of data obtained in tracking the projectile over the first portion of its trajectory. A quasilinearization technique is developed which allows a determination of those trajectory parameters yielding the best least-squares fit to observations. The paper is concluded by a consideration of some of the properties of the measurements which will actually be made by the radar. It is suggested that some improvement in the character of the system parameter estimates could be effected by utilizing cost functionals other than the usual sum of the squared deviations.

VIIC.4 Cost Effective Army Material Testing, *GLEN BENZ, Genge Industries, Inc., Scientific and Consulting Division, 4419 Van Nuys Blvd., Sherman Oaks, California 91403.*

Alternative criteria for demonstration testing of Army material are analyzed for cost effectiveness. Fixed sample and sequential test methods are examined using binomial, chi-square, student's "t" and Bayesian techniques. Tradeoff examples are given for testing life percentiles of gun barrels and engine-powertrain subsystems, and for testing percentiles and means of maintenance times and times-between-failures of armament-vehicle systems. Guidelines are set up for Project Managers in selecting requirements, confidence limits, sample sizes, test durations and test methods for various phases of procurement. In particular, an approach to cost-effective demonstration testing of ammunition and of expensive, long-lived systems is suggested.

VIID.1 A Review of the Apollo Applications Program Orbital Workshop Experiments, *JACK H. WAITE and ALEX L. MADYDA, National Aeronautics and Space Administration, Marshall Space Center, 35812.*

The first NASA flights whose objectives are to conduct space experimentation will be the initial cluster flights of the Apollo Applications Program (AAP-2/AAP-1). On these two flights, the orbital workshop will be activated, and engineering and technology experiments, medical experiments, and science experiments will be conducted in the orbital assembly. This paper will be discussing the experiments to be conducted during the 28 day mission and will present a discussion of the problems associated with integrating the experiments into their carrier and the mission.

VIID.2 A Review of the Apollo Applications Program ATM Experiments, *ARTHUR F. WHITE, JR., National Aeronautics and Space Administration, Marshall Space Flight Center, 35812.*

The fifth flight of the current Apollo Applications Program will consist of groups of solar observation experiments mounted on the ATM Rack and a control center contained in a modified LM. This payload will dock to the orbital assembly resulting from earlier flights, and long term, detailed observations of the sun will be conducted. These solar experiments will observe the sun in the ultraviolet, white light, and X-Ray spectrums in both the quiescent state and flare state. This paper will discuss each of the ATM experiments and will also discuss the problems associated with integrating the experiments into their carrier and the mission.

VIID.3 A Review of the NASA Astronomy Program, *JESSE L. MITCHELL, Director, Physics and Astronomy Programs, and MARCEL J. AUCREMANNE, Office of Space Science and Applications, National Aeronautics and Space Administration, 20546.*

One of the objectives of the NASA science programs is to perform detailed observations of the sun and the celestial sphere. Currently in orbit are the OSO and OAO satellites making remote surveys of the sun and celestial sphere. This paper will discuss the current NASA science program of solar and stellar observations and some of the recently obtained results.

In addition, a discussion of future observation programs of the sun and stellar bodies will be presented and the impact of the use of manned flights will be discussed.

VIII.4 Space Systems Possibilities for Global Atmospheric Research Programs, *MORRIS TEPPER, Deputy Director, Space Applications Programs, Office of Space Science and Applications, National Aeronautics and Space Administration, 20546, and STANLEY RUTTENBERG, NCAR, Boulder 80302.*

One of the objectives of the NASA science program is to perform detailed observations of the Earth for weather studies, and geographic, geologic, agricultural studies. The TIROS satellite is currently transmitting weather pictures from a synchronous orbit and the Mercury, Gemini, and Apollo programs have obtained limited photographs of the Earth's surface. This paper will present some of the results obtained from the above projects and will discuss future NASA programs with regards to the ATS satellite, Apollo Applications Program, and the Applications A and B payloads.

VIII.5 Agricultural Resources Information System—The User's Point of View, *HAROLD G. LORSCH, Consulting Specialist, Advanced Requirements, Missile & Space Division, General Electric Company, Valley Forge Space Technology Center, King of Prussia, Pa.*

Agriculture appears to be a highly fruitful area for the application of aerospace technology to the better management of Earth resources. The constantly changing agricultural environment makes the repetitive collection of information over the same ground area a necessity for the user. Satellite instrument carriers are well suited to this type of data collection. The paper describes the results of a survey undertaken to determine the agricultural information requirements of non-governmental users. The great number and variety of potential users lead to greatly differing information needs with regard to type, timing, frequency, format, levels of resolution and aggregation. These requirements vitally affect the design, operation, and cost of any proposed agricultural resource information system.

VIII.1 Linear Programming in Occupational Medicine, *JAMSHED MODI, Research Triangle Institute, Durham, North Carolina 28806.*

Preventive health programs represent an important part of occupational medicine. The medical procedures for these programs have up to now been chosen without quantitative analysis of their operational and financial effect for the sponsoring employer. This paper develops a measure of the "worth" of medical procedures and shows how a linear programming model can be set up to maximize the total worth of all procedures, staying within constraints of medical personnel availability. Numerical results of full scale application of the model might be available at the time of the meeting, but in any case the model will be illustrated with a numerical example.

VIII.2 A Heuristic Distribution and Allocation Model for Whole Blood, *C. CARL PEGELS, Associate Professor of Management Science, and ANDREW E. JELMERT, Instructor of Management Science, School of Management, State University of New York at Buffalo, Main Street, Buffalo, New York 14214.*

The problem discussed in this paper is how to equitably distribute and allocate scarce and perishable whole blood from a central collection and inventory location to a large number of user blood banks served by the central collection agency. This problem is typical of most regional and urban central blood banking systems.

The proposed model will allocate the available blood on the basis of expected demand, blood requests, current central inventory, and historical demand. A heuristic allocation model with several analysis submodels will be used to allocate the available blood so that probabilities of disruptive shortages are minimized.

VIII.3 Cost-Effectiveness Analysis of Artificial Kidney Systems, *JAMSHED MODI, Research Triangle Institute, Durham, North Carolina 28806.*

This paper describes a scheme to study the relative desirability of several artificial kidney systems commonly used to sustain patients whose own, natural kidneys have deteriorated. A brief introduction on artificial kidney technology is followed by a description of how a cost-measure was developed. The cost-measure developed includes components of acquisition costs, manpower costs, material costs and "social disruption costs." The effectiveness-measure is based on observed condition of patients rather than on performance measurements on the equipment. Numerical results of the analysis will not be available.

VIII.4 Optimal Planning of an Emergency Ambulance Service, *COLIN E. BELL, University of California at Irvine, Irvine, California 92664, and DAVID ALLEN, Dunlap and Associates, Darien, Connecticut 06820.*

Queueing theory models are developed for computing the size of emergency ambulance fleet required to meet minimum standards of service. As a function of the demand for ambulance service and the distribution of duration of service calls, tables are given for the number of ambulances required to respond immediately to 95 (or 99) percent of service requests.

By analyzing a queueing system with unlimited server (ambulance) availability we provide approximate results to overcome the difficulties of computing steady-state results for a multi-server (ambulance) queueing system.

Our results provide guidelines for operating an ambulance fleet based at a single garage. We discuss the extension of our results to more complex situations.

VIIF.1 A Universal Thermal Flux Simulation System, *RAYMOND L. CHUAN, and DONALD A. WALLACE, Advanced Technology Gp., Atlantic Research Corp., Costa Mesa, Calif. 92626.*

This paper deals with the development of a system to simulate both the thermal radiant energy input to a spacecraft from the sun, and that from a planet. Past efforts in simulation techniques for the design and testing of spacecraft have stressed only the solar radiation. Since 35% of the total maximum thermal radiation a spacecraft receives in Earth orbit comes from the planet, a significant gap in simulation technology exists.

This paper deals with the problems associated with developing feasible simulation techniques under laboratory conditions. A proposed system consisting of a Direct Analog Simulator and a Zone Controlled Thermal Flux Array is discussed.

VIIF.2 Protection of Spacecraft from Test Equipment Transients During Thermal-Vacuum-Solar Tests, *R. ELLISON, Martin-Marietta Corporation, Denver.*

The characteristics of test equipment transients that invalidate long duration T-V-S tests of spacecraft are described; the dominance of common mode interference from monitoring and power circuits is described. The transient susceptibility of spacecraft is shown to be predominantly common mode.

Criteria for control of interference entering the test chamber and for control of interference originating within the test chamber are given.

VIIG.1 The Need for Automatic Test Facilities for Large-Scale Arrays, *EDWARD SARKISIAN, NASA/Electronics Research Center, Cambridge, Mass. 02139.*

The seriousness of the component-testing problem has become particularly obvious within the last year. Up until that time, even the integrated circuit did not seem to impose an overwhelming testing problem. However, with LSI appearing on the brink of success, the

development of sophisticated component test equipment is not only desirable but an absolute necessity. Many companies are already involved in developing LSI testing techniques but many problems are still unsolved. In fact, many of these problems are not even understood. A major problem is that there are so many different approaches to fabricating LSI chips that there is little or no communication among companies about how to test the final circuits.

VIIG.2 Transient Response Testing of Lumped Systems, *S. C. GUPTA, Information and Control Sciences Center, Institute of Technology, Southern Methodist University, Dallas, Texas 75222.*

Transient response testing of lumped electrical circuits or systems involves the determination of transient response analytically for checking it against the actual system. This analytical determination can be done by the computer from the knowledge of transfer functions. A computer program has been developed which enables one to use the logic of Laplace Transform operations to obtain time response from transfer functions and store it in the computer to check it against the actual lumped component or system.

A brief survey of the rules is followed by a description of the program logic and grammar. The limitations of the program have been listed and illustrative examples added to indicate its use.

VIIG.3 Topological Applications in Fault Diagnosis of Linear Systems, *S. PARK CHAN, Prof. of Electrical Engineering, University of Santa Clara, Santa Clara, California.*

A general procedure for fault detection and isolation in a linear network by measuring only the magnitude of the transfer function at certain selected test frequencies is described.

A set of definitions (test frequency, gain signature, fault dictionary, etc.) will be introduced. The theoretical basis for formulating the test procedure is discussed. Techniques for generating the symbolic transfer function as part of the procedure are described and a comparison between these techniques based on topological considerations is made. The problem of partitioning large networks into subnetworks by the use of topological formulas in developing the symbolic cofactors of the transfer function is investigated.

Finally, extension of the techniques developed to fault isolation in linear systems (modules versus components) and the associated topological considerations are discussed.

VIIG.4 An Algebraic Theory of the Analysis and Testing of Digital Networks, *A. BROWN, D. D. JOHNSON, and H. YOUNG, Dept. C83, Building 931, Systems Development Division, IBM Corp., Poughkeepsie, N. Y. 12602.*

This paper summarizes the development of an Algebraic Logic Network Analysis (ALNA) theory which will enable a designer to specify the optimal level of testability commensurate with mission requirements.

A model of a device is obtained from a structural description. Solving the system of equations leads to network transfer functions characterizing phenomena observable at the interfaces. The determination of test conditions is transformed into a problem of solving an appropriate system of variational Boolean equations.

These results are independent of design complexities and are applicable to both combinatoric and sequential devices.

VIIG.5 Combinatorial Analysis for Check-Out Techniques, *EMIL C. NEU, Assistant Professor of Electrical Engineering, Stevens Institute of Technology, Hoboken, New Jersey 07030.*

Often multiterminal networks have only their external terminals available for measurement and testing. Combinatorial techniques have been used previously to enumerate the x-terminal y-port nonredundant subnetworks which can be generated from a z-terminal parent network of this type.

This paper discusses new techniques for using measurements on these subnetworks to detect the presence of any internal network faults and to determine their location. The problem of ascertaining which set or sets of measurements best isolates these faults is analyzed. Computerized techniques of testing, based on the sensitivity of these measurements to network parameters are presented.

VIII.1 Long Life Reliability Problems and Solutions for Valves Under Spatial Environments, *J. C. DuBUISSON, Reliability Section, Martin Marietta Corp., Denver Division.*

The objective of this study was (1) to determine the adverse effects of prolonged exposure (up to ten years) to space environments upon valve reliability, and (2) to determine and recommend means to either delete or alleviate these adverse effects and enhance long life reliability.

VIII.2 Machine "Reading" of X-Ray Film, *J. NERI, Senior Quality Engineer, and J. C. PERNICKA, Associate Research Scientist, Martin Marietta Corp., Denver, Colo.*

The use of electronic and optical techniques to sort, characterize and analyze x-ray film images is discussed. Various types of equipment and basic approaches to the problems of semi- and fully automatic-reading of film are evaluated. Examples and prototype set-ups are shown along with typical processing of films to be "read".

VIJJ.1 Economical Planetary Transfers in the Real Planetary Cases, *J. P. GRAVIER, C. MARCHAL, and R. D. CULP, Dept. of Aerospace Engineering Sciences, U. of Colorado, Boulder, Colo.*

The theoretical economical solution of Hohmann for the planetary transfers corresponds to the case of circular and coplanar orbits.

In the Solar system the eccentricities and the inclinations are not at all negligible and the real optimal solutions are sometimes very far from the theoretical solutions of Hohmann. They depend very much on the planetary window of interest.

The economical transfers Earth-Mars, Mars-Earth, Earth-Venus, Venus-Earth are studied numerically either in the case of utilization of a final atmospheric braking or not (in terms of the planetary window).

VIJJ.2 Optimum Transfer Between Hyperbolic Asymptotes About a Planet of Finite Size, *J. M. WALTON, C. MARCHAL, and R. D. CULP, Dept. of Aerospace Engineering Sciences, U. of Colorado, Boulder, Colo.*

For some planetary missions it proves advantageous to make hyperbolic trajectory changes while in the sphere of influence of one of the planets. This leads directly to the problem of transferring from one hyperbolic asymptote to another in such a way as to minimize the characteristic velocity of the maneuver. The general problem can always be reduced to a two-dimensional problem. The tools of both the theory of maxima and minima and the calculus of variations are required to obtain the absolute optimal maneuver. These absolute optimal maneuvers consist of at most two finite impulses and four infinitesimal impulses. A complete cataloging of the optimal maneuvers is provided.

VIII.3 Decision Policies for Midcourse Corrections to the Trajectory of a Space Vehicle, JOHN T. WAGNER, TRW Systems.

Optimal maneuver strategy is examined for four representative performance criteria associated with the midcourse guidance of space vehicles. The following questions are answered.

Should velocity corrections to the trajectory of a spacecraft be made at fixed times? What is the desired time duration of each maneuver?

What is the maneuver that minimizes certain representative functionals associated with departures from phantom intermediate targets along the planned course or the final target, and either satisfies minimal fuel properties or inequality constraints on control?

Should the commanded correction null the estimated pre-maneuver miss, or should the trajectory be under-corrected for fuel savings?

The resultant decision policies are compared with standard logic for guiding probes during the midcourse phase of deep space missions.

VIII.4 Non-Linear Longitudinal Dynamics of an Orbital Lifting Vehicle, N. X. VINH, Associate Professor, Dept. of Aerospace Engineering, The University of Michigan, Ann Arbor, Michigan 48104, and A. DOBRZELECKI, Capt. USAF, Air Force Weapons Laboratory, Kirkland AFB, New Mexico.

This paper presents an analytical study of the longitudinal dynamics of a thrusting, lifting, orbital vehicle in a nearly circular orbit.

It is found that the translational motion is composed of a non-linear oscillation, or phugoid, and a spiral mode which results in a decay or a dilation of the orbit depending on the perturbed initial conditions. The non linear effects on the phugoid period and damping are small in the altitude range considered. The elements of the orbit, i.e., radial distance, velocity, flight path angle were obtained explicitly as functions of the time. The behaviors of the variations of these elements are correctly predicted. It is shown that there exists an altitude where there is an inversion in the change of the velocity.

VIII.5 Spacetrack Simulation Model, L. L. WEBER, Computer Sciences Division, Computer Sciences Corporation, Colorado Springs, Colorado.

Computer Sciences has contributed to the development of a simulation model of the Space Defense System for the U.S. Aerospace Defense Command. The model, written in SIMSCRIPT for application on the Philco 2000-212 computer, provides evaluation of the performance of the current space defense system, as well as planned or proposed systems.

The simulation model includes man-made space objects, all major sensor systems, communications links, computer configurations, software and operational procedures. Modular and flexible in nature, it provides both a model for traffic analysis and a model for the accuracy with which the orbits of space objects are determined and corrected.

The basic model is being expanded to provide more refined models for orbit correction accuracy, phased array sensors, and mission planning and execution procedures.

VIIIA.1 Lunar Sinuous Rilles, HAROLD MASURSKY, Chief, Branch of Astrogeologic Studies, United States Geological Survey, Flagstaff, Arizona 86001.

Lunar Orbiter photographs allow reexamination of sinuous rilles at a resolution of two meters in a few cases and at a resolution of 50 to 100 meters on most of the Moon. The rilles or rimae can be divided in three groups: 1) those that originate in craters and meander downhill on to mare basin basin floors; 2) those that meander in branching patterns on

¹This work was supported by NASA Contract No. NASr 54 (06).

surfaces of low relief; 3) those that occupy sinuous channels within linear, curving, or rectilinear graben that appear to be tectonically controlled.

Three origins have been proposed: 1) liquid lava drainage channels; 2) particulate volcanic flows of the nuee ardente type; 3) violently turbulent flow of solid materials partially buoyed up by included gases, and liquid water flows with suspended load of fragmental material.

Possible mechanisms for the formation of the rilles are discussed.

VIIIA.2 The Effect of Use of Lunar Resources on Lunar Logistics and Earth-lunar Transportation, *ERNST STEINHOFF, Chief Scientist for Air Force Missile Development Center, Holloman Air Force Base, Alamogordo, New Mexico 88310.*

Reports of the Working Group on Extraterrestrial Resources have concluded that if water is extractable from the moon and planets, spaceflight to these bodies can benefit from the use of this water as a raw material for fuel and over 90% of the raw material required to support manned expeditions. The alpha scattering experiment of Surveyors 5-7, while not able to determine the hydrogen content of the lunar crust, has been able to confirm an average oxygen content of 57 percent.

This indicates that either oxygen and chemically bound or liquid water may be expected on the moon. The findings point to the promise and need for reusable spacecraft, refuelable on the moon, which could usher in a period of space operation in which Earth-lunar transportation cost could be lowered to somewhere between 75 to 10 percent of current lunar transportation cost. This conclusion calls for emphasis on reactor designs of long life, of the need for design of water or oxygen extraction and processing equipment on the moon, and emphasis on reusability in a lunar transportation system. Such a logistics system could be in use ten years from now.

VIIIA.3 Water Under the Lunar Surface, *THOMAS GOLD, Director, Center for Radio Physics and Space Research, Cornell University, Ithaca, New York 14850.*

The temperatures beneath the lunar surface down to certain depths are such as to lead to the expectation of a wide-spread permafrost layer which would trap ground water beneath it in the warmer interior.

The accessibility of possible lunar water resources and their implications for efforts in space are discussed.

VIIIB.2 Project CAIC Cities-Aerospace Industry Coalition, *SHIRLEY THOMAS, Chairman, Mayor's Space Advisory Committee, City of Los Angeles, California 90012.*

The urban crisis ranks as one of today's major issues facing this nation. Many of the problems inherent in this morass are ones that appear amenable to solution by the innovative technology and systems approach of the aerospace industry. To date, however, cooperative efforts have not brought any notable success.

Project CAIC has been formulated to obviate past stumbling blocks and to provide a platform from which the 77 cities of Los Angeles County and the aerospace industry may join in an activity that can serve as a pilot project for the entire nation.

VIII.B.3 One Answer from the Aero-Space Industry on Low Cost Housing, *D. H. CHRISTENSEN, Director of Marketing and Administration, Panel Lock Housing Division, Lockheed Aircraft Service Company, P.O. Box 33, Ontario, Calif. 91754.*

The Panel Lock construction system, developed by Lockheed Aircraft Service Company, a Division of Lockheed Aircraft Corporation, offers a low cost technique for building panelized housing of concrete, steel and aluminum. Engineered to conform to the rigid specifications of FHA and the building codes of typhoon and earthquake areas, Panel Lock homes are now found in Puerto Rico, Guam, the Philippines, Indonesia, Australia, Panama, Texas and California. This versatile system, based upon a modular concept, can be adapted to an enormous variety of floor plans and sizes.

VIII.B.4 Climate as a Factor in Community Environmental Management, *J. F. CLARKE and DeWITT BAULCH, Special Projects Training Operations, Cincinnati Training Program, TMD, Environmental Control Administration, Cincinnati, Ohio 45202.*

The natural atmospheric environment exerts a strong influence on both the psychological and physiological health of man. The high density of concrete structures and artificial heat source characteristic of today's city often modify the urban environment significantly compared to that of adjacent rural environs.

This presentation deals generally with the three topics: (1) the degree to which the climate is modified through urbanization, (2) an example of the hazardous effects of the urban climate-heat deaths, and (3) a brief discussion of the climatological aspects of urban planning.

VIII.B.5 Dynamic Land Inventory System, *JUDITH MOSS, Lockheed Company, Systems Consultant, Government Information System, Sunnyvale, California 94088.*

Land use planning must begin with detailed knowledge of individual parcels which can then be arranged in meaningful ways for correlation with other economic and social data. A land information system must provide not only a current snapshot of the city but also historical patterns relate to other factors. To meet these requirements a dynamic land inventory system is being developed for a city of 100,000 population.

VIII.C.1 A Radiometer for Measuring Solar Flux Variations, *ROGER C. LINTON, National Space and Aeronautics Administration, Marshall Space Flight Center, Alabama 35812.*

The lack of sufficient radiometric precision and the inability to eliminate effects of atmospheric turbulence has prevented a satisfactory determination of the actual stability of the solar constant. If variations do exist, the magnitude is probably less than the sensitivity of most radiometers. A radiometer was developed to provide plus or minus 1.0% accuracy and a precision of 0.01%. The designed performance was verified using an evacuated hohlraum cavity as a standard. A discussion of the novel features which give this instrument its extreme sensitivity, and the advantages of using such a sensor for spacecraft measurements are included. The essential feature of this radiometer which distinguishes it from all others involves the utilization of alternating current circuitry to limit the controlling parameter to a frequency. The radiometer concept has been validated and a working unit is presently being tested.

VIII.C.2 Deployment of a Tethered Orbiting Interferometer, *C. J. SWET and J. M. WHISNANT, Applied Physics Laboratory, The Johns Hopkins University, Silver Spring, Maryland.*

Among the candidate configurations for the Radio Astronomy Explorer C and D spacecraft

is a tethered orbiting interferometer, consisting of two end bodies joined by a flexible light-weight cable several kilometers long. One version has a fifteen meter dipole antenna on each end body, mounted colinearly with the tether, the entire structure being gravitationally stabilized with its long axis geocentrically aligned. The system is Delta-launched into Earth orbit as a single payload.

A particularly simple two stage method of in-orbit deployment is described. The first stage is an impulsive separation of the initially joined end bodies to a predetermined tether length, resulting in librating gravitational capture. The second stage removes libration by a further "deadbeat" extension to the intended final length. Some limits of utility are defined parametrically using a point mass dynamical simulation, engineering and operational aspects are discussed, and possible refinements and adaptations of the concept to other missions are explored.

VIIIC.3 A Multi-Function Radar Sensor for Deep Space Probes, *WERNER KOPPL, Department Staff Scientist, Space Sciences Department, Martin Marietta Corporation, Denver Division 80201.*

Deep space missions for planetary exploration require small, reliable, light weight instrument payloads for remote sensing of planetary atmospheres and surfaces. This paper describes the design of a small, multi-function radar sensor, which in a single, integrated package is capable of performing the following measurements from a deep space probe.

- (1) radar altitude above planetary surface,
- (2) planetary surface reflectivity and roughness,
- (3) vehicle attitude and angle of attack,
- (4) vehicle velocity.

All of the above information can be extracted from a small, compact FM-CW radar sensor which performs continuous measurements of range, velocity, and surface reflectivity from a deep space probe platform. The radar employs multiple, solid-state transmitter/receiver modules and a small, planar phased array antenna. Multiple-beam operation of the radar permits simultaneous recordings of the above parameters and provides the capability for mapping planetary surface reflectivity and surface roughness contours. The system is completely independent from other on-board sensors.

VIIIC.4 The Role of Imagery in Unmanned Planetary Orbital Exploration, *DAVID A. KLOPP, Research Physicist, Astro-Science Center, IIT Research Institute, 10W. 35th Street, Chicago, Illinois 60616.*

In order to define, in gross terms, the imaging equipment required to explore the planet, the scientific requirements for orbital imaging experiments have been derived. A systems analysis approach identifies those physical phenomena whose observation can reasonably be expected to materially increase our knowledge of the planets and, ultimately, the origin and evolution of the solar system. For each phenomenon, the efficacy of imaging, in providing the desired information is evaluated. Unlike most analyses, imaging is not associated with a specific technological capability. It is found that the visible portion of the spectrum is the most useful spectral region for exploration of the Moon, Mars, and Mercury. Radar imaging provides the most useful information at Venus, while at Jupiter infrared imaging is most useful.

VIIID.1 Deterministic Limits of Probabilistic Lanchester Systems, *DANIEL O. ETTER, JR., Systems Evaluation Division, Institute for Defense Analyses, 400 Army-Navy Drive, Arlington, Virginia 22202.*

This paper applies the theory of stability and convergence for finite difference schemes to the problem of showing that trajectories of stochastic Lanchester systems converge in probability to trajectories of deterministic Lanchester equations in the limit of large engaged force levels. The conclusion follows from Lax's equivalence theorem. The approach taken here complements the alternative of using Laplace transforms, in that a different

body of theoretical apparatus is brought into play, with different advantages and restrictions.

VIIID.2 Optimum Blocking Tactics for Border Security Systems, A. W. DOBIESKI and R. E. WONG, TRW Systems Group, One Space Park, Redondo Beach, Calif. 90278.

Border Security Systems prevent intruders from crossing a particular line or border and employ detection and acquisition devices as well as blocking forces. Given detection and acquisition of the intruders has occurred, the problem is to select the optimum or the most cost effective blocking tactic. In this paper equations which describe the effectiveness and cost of both fixed and mobile blocking forces are derived for several situations. Results include deployment geometry associated with minimum cost as well as sensitivity analyses, and conclusions are made as to the best tactic for a particular situation.

VIIID.3 Conus Air Defense Engagement Simulation (CADENS), OLEG V. FEDOROFF, HORACE C. LORCK, and ROBERT A. PATCHETT, Braddock, Dunn, and McDonald, Inc., 2105 E. Bijou Street, Colorado Springs, Colorado 80909.

CADENS is a large scale, operation-oriented, event-stepped, Monte Carlo simulation depicting the effectiveness of a CONUS-wide deployment of a mix of ballistic missile defenses, surface-to-air missile defenses, and manned interceptors against a mixed ballistic missile and air threat in an assumed high-intensity nuclear environment. CADENS simulates the operation of each defensive system and threat system in sufficient detail to make results sensitive to significant changes in the performance characteristics of either type system. CADENS was developed as a tool to assist in force level studies, deployment analysis, stockpiling studies, general system effectiveness, and systems interaction.

VIIID.4 An Economic Analysis of Air Force Mission Support Program Alternatives, WILLIAM GRODOWITZ, Special Assistant for Program Evaluation, Directorate of Aerospace Programs, Headquarters United States Air Force, Washington, D. C. 20330.

This paper illustrates a generalized computational and graphical methodology for determination of the efficient size and composition of the Air Force auxiliary mission support transport fleet given operational requirements and constraints for military training sorties and military or commercial air transportation.

The particular problem posed permitted an unique graphical and computational solution as a function primarily of the total passenger miles accomplished by commercial air.

Linear programming techniques can accommodate more general cases of this kind as well as dramatic variations in parameters and constraints. An example of linear program formulation and equation sets are given in the paper.

VIIIE.1 Techniques For Space System Cost Analysis Based on System Design Characteristics, JOSEPH A. NEISS, Member of the Technical Staff, Aerospace Corporation, 2350 E. El Segundo Blvd., Los Angeles, Calif. 90045.

This paper discusses techniques of analysis of system cost-elements which are sensitive to basic characteristics such as L/D, payload, mission duration, propulsion design and sub-system selection. In-depth cost-analysis of large numbers of configurations, operational modes, and traffic rates, is required to permit meaningful total system cost-comparisons.

Fourteen major systems parameters are examined in this sensitivity analysis. Employment of these techniques allows the system cost-analysis to effectively weight relative values of program alternatives, and identify optimized approaches in terms of resources, schedules and desired program results.

VIII.E.2 Launch Vehicle/Mission Assignment Model, *C. J. GOLDEN, Lockheed Missiles and Space Company, Systems Evaluation, D51-30/538, Post Office Box 504, Sunnyvale, California (415-743-1105) 94088, and E. M. Van VLECK, Special Projects Office, NASA Mission Analysis Division, Moffett Field, California 94035.*

The complexity of space flight programs requires that efficient selection of future launch vehicle development programs be employed in order to minimize total costs. This objective can be achieved only by requiring that any future fleet of launch vehicles capable of accomplishing some future range of missions do so at lowest total cost (including recurring, non-recurring and sustaining costs).

A model was developed which includes these sustaining costs in the basic branch-and-bound algorithm. In addition to obtaining an overall optimum, the program developed also automatically calculates suboptimum solutions so that sensitivity of total cost to vehicle mix is available.

VIII.E.3 Budget Smoothing Model for Program Planning, *ROBERT E. SLYE, Special Projects Office, NASA Mission Analysis Division, Moffett Field, California 94035.*

In program planning, it is desirable to have an automated means of scheduling various projects within an overall framework subject to certain constraints such as the overall funding available and the time dependence of one project on another.

To accelerate the "budget smoothing" process, and to utilize available costing data objectively for budget accounting and planning purposes, an iterative methodology has been conceived and written into a computer program. The iteration is based on least squares wherein the finally selected program offers the minimum rms deviation from the budget plan. Smoothing is accomplished by modifying the development schedules and target dates of the subprograms, subject to overall program constraints and priorities.

VIII.G.1 Optimal Economic Design of a Queueing System, *IRWIN W. KABAK, Associate Professor of Operation Analysis, New York University, 100 Trinity Place, New York, N.Y. 10006.*

A queueing system of the type M/M/s: (s+N) is assumed. The expected value of the cost function per unit of time to operate this system is given. The cost function has the following components: facility cost, cost of waiting positions, the revenue (a function of the probability of an arrival being dismissed from the system), a loss function dependent upon dismissals from the system and a cost for the number of arrivals in the system. The average cost is then minimized by a proper choice of the variables subject to control.

VIII.G.2 One-Machine Sequencing to Minimize Total Tardiness, *HAMILTON EMMONS, Dept. of Operations Research, Upson Hall, Cornell University, Ithaca, N.Y. 14850.*

This paper considers the problem of sequencing n jobs with arbitrary processing times and due dates on one machine to minimize total tardiness. Theorems are proved which establish the relative order in which pairs of jobs should be processed in an optimal schedule. The power of the theorems is sufficient to permit the jobs to be completely ordered in many cases, thus solving the problem without any searching. In particular, corollaries establish more general conditions than are currently recognized under which sequencing in order of non-decreasing processing times and sequencing in order of non-decreasing due-dates are optimal. In general, even large problems can be at least partially ordered to the point that very few schedules remain to be searched. An algorithm is proposed which should economically order hundreds of jobs.

VIII.G.3 An Algorithm for the Design of Markovian Congestion Systems, *HILLEL KUMIN, Assistant Professor, The University of Oklahoma, Norman, Oklahoma 73069.*

An algorithm is proposed for the design of a class of Markovian congestion systems. The class is characterized by almost triangular transition matrices. A feature of the algorithm is

that it does not utilize closed-form expressions for the steady-state behavior of the system. Convergence is discussed and conditions given for the convexity of a special class of non-linear objective functions.

VIII.4 On A Class of Queueing Problems And Discrete Transforms, *S. SUBBA RAO, University of Rochester, Rochester, N. Y. 14627, and N. J. JAISWAL, Defense Science Laboratory, Delhi-6 (India).*

The main object of the paper is the demonstration of a method by which a number of problems arising in the study of impatient customers in queues can be solved. When there are a finite number of states it has been shown that at least formal solutions can be obtained through matrix algebra. The use of matrix algebra results in what are called "discrete transforms." The results are explicitly given when the balking and reneging coefficients are linear in n . An alternative method in which the spectral resolution of matrices is used is also given for solution of the set of equations. Finally, the methodology used for the M/G/1 case is shown to hold for similar problems in the GI/M/1 case.

VIII.1 Automatic Test—An Overview and Classification, *WILLIAM A. HEFFNER, Chief Advanced Digital Applications, Martin Marietta Corporation, Denver, Colo. 80201.* Present automatic test systems vary widely in configuration, objectives, and capabilities. Techniques range from simple mechanization of manual procedures to sophisticated interaction with a computer. Communication is difficult because of the lack of a precise language or analytic structure.

Such systems can be analyzed in terms of a set of characteristics, which can then be used for description and evaluation. This new paper proposes a classification scheme, terminology and definitions, and an approach to evaluation criteria.

The subject is first treated from a conceptual viewpoint. Current usage is then described, and future trends are projected.

VIII.2 Fault Diagnosis of Operational Synchronous Digital Systems, *MICHAEL J. DEVANEY and GEORGE W. ZOBRIST, Department of Electrical Engineering, University of Missouri at Columbia, Columbia, Mo. 65201.*

The paper presents an original approach to diagnosing faults on operational synchronous digital systems, by partitioning the diagnosis problem into fault detection of single and distinguishable multiple faults, and fault location down to the defective module or package. Effort has been exerted to minimize computer time and storage requirements so that it may operate effectively on a time-shared on-board computer. The effectiveness of the approach is demonstrated by its application to a Boolean model of the Gemini's Electronic Timer.

To the authors' knowledge the paper offers a new approach and the material has not been published elsewhere.

VIII.3 A Standard Language for Automated Testing of Electronic Components, *R. L. BEADLES, Member of Technical Staff, Engineering and Environmental Sciences Division, Research Triangle Institute, P. O. Box 12194 Research Triangle Park, N. C. 27709.*

Research Triangle Institute is conducting for NASA/ERC a survey study of the feasibility of a standard language for automated testing of electronic components. The large expenditure typically required for developing new software for each new automated test system is undesirable and may be unnecessary. Via document searches, mail surveys and direct contact with key testing personnel in industry, an information base has been obtained for the study.

A number of procedure-oriented languages (*compilers*) for automated testing have been identified. Based upon experience with these languages and upon NASA needs, a specification of a standard language for automated testing of electronic components is being prepared. Cost savings resulting from, and problems associated with, adoption of a standard language are exploited.

VIIII.4 Trend Data Analysis in Automatic Testing, *D. L. BALDWIN, Unit Head, Quality Technical Development, Martin Marietta Corp., Denver, Col. 80201.*

A method for conveniently using existing statistical techniques to provide timely information on electrical piece-part or component behavior is potentially available through computer-aided testing systems. If the appropriate computer software were developed, test data stored on memory files directly accessible by the test system computer could be automatically used to predict the expected behavior of a device under test and to compare its performance with respect to similar devices.

This presentation will describe the advantages of on-line trend data analysis in an automatic test system, define a specific trend data analysis program and illustrate how the analysis can be used for design, procurement and production control.

VIIII.5 Computer-Aided Testing of Integrated Circuits, *E. C. BERTNOLLI, F. J. KERN and R. C. PEIRSON, Department of Electrical Engineering, University of Missouri—Rolla, Rolla, Mo. 65401.*

This paper contains a synopsis of recent research results on the application of reciprocal time domain techniques to computer-aided testing of integrated circuits. Also included is a description of a hybrid computer test system that has the capability for automatic impulse and model reference testing of analog integrated circuits. The ideas that are basic to impulse and model reference testing and the methods used to implement these ideas are summarized. This paper represents an application of some new and some well known techniques to the construction of a computer-aided integrated circuit test system.

The work reported here was sponsored jointly by the University of Missouri—Rolla and by the NASA—Electronics Research Center under grant NGR 26-003-037.

VIIII.1 An Improved Model of the Upper Atmosphere (90 to 1000 km Altitude), *DON K. WEIDNER, Aerospace Environment Division, George C. Marshall Space Flight Center, National Aeronautics and Space Administration, Huntsville, Ala.*

Current upper atmospheric models do not adequately represent the atmosphere below 200 km altitude due to the constant boundary assumptions at 120 km altitude. An analysis of available rocket-borne spectrometer measurements and satellite drag determined density data has generated an improved upper atmospheric model. Results of this study have also indicated the well-known, controversial factor-of-two difference, between density as determined from satellite drag data and the density obtained from mass spectrometers, to be unreal. The difference is indicated to be a result of incorrect assumptions made in comparing the drag densities to the gauge measurements.

VIIII.2 An Evaluation of Updated Atmospheric Density Models Based on Satellite Lifetimes, *HARRY W. GATZKE, Dynamics and Guidance Department, Lockheed Missiles and Space Company, Huntsville, Ala., DON K. WEIDNER, Aerospace Environments Division, George C. Marshall Space Flight Center, Huntsville, Ala.*

For close-Earth satellites the dominant factor which perturbs the conic orbit is aerodynamic drag. Satellite lifetime prediction is therefore limited in accuracy by our limited knowledge of atmospheric density. Several density models are now available and are continually being updated as more information is obtained.

This study evaluates some current density models. Lifetimes of satellites which have

decayed are computed using these density models in a satellite lifetime program. For each model and for each satellite, a numerical measure of the difference between the computed and the actual lifetimes is then calculated. For each density model, the mean, range, and standard deviation of measures of difference are determined.

The accuracy of satellite lifetime prediction is also limited by errors in assumed initial orbital elements and ballistic coefficients. Satellites whose computed lifetimes indicate significant errors are next disregarded. The mean, range, and standard deviation are recalculated for each density model and are used as indicators of the accuracy of the model.

VIII.3 Swept Frequency Microwave Measurements in Simulated Reentry Environments, *R. P. DAVIDSON, R. J. CHURCHILL and J. P. RYBAK, Electrical Engineering Department, Colorado State University, Fort Collins, Colo. 80521.*

Measurements of reentry antenna properties are difficult to relate to plasma sheath characteristics using single frequency measurement techniques because the plasma environment presents several variables which affect antenna admittance. The swept frequency X-band reflectometer (Figure 1) determines plasma layer properties by measuring the antenna admittance for a number of frequency values. Unlike other instruments of this type, the amplitude and phase of the reflected wave are simultaneously measured, which permits wideband (8.2-12.4 GHz) swept frequency phase measurements with an accuracy of $\pm 10\%$ and a resolution of 0.1 degree. Admittance measurements for dielectric layers contiguous to an aperture antenna have been compared to theory, and it is concluded that this technique allows accurate determination of properties of simulated reentry sheaths.

VIII.4 Dominant Electron Cooling Processes in the Ionosphere, *WILLIAM T. ROBERTS, Aerospace Technologist, Aerospace Environment Division, Aero-Astrodynamic Laboratory, George C. Marshall Space Flight Center, Huntsville, Ala.*

A study of the predominant heating processes in the ionosphere is currently in progress. These processes include elastic collisions between electrons and the individual neutral and ion species present, as well as inelastic processes such as rotational and vibrational excitation and fine structure excitation of atomic oxygen. In addition, we calculate the coefficient of thermal conductivity and examine its change with altitude.

On January 24, 1967, a series of six thermospheric probes were flown from which the electron and neutral densities and temperatures have been derived. These data will be used in the comparison of the electron cooling processes.

VIII.5 Diffusion Treatment of Thermospheric Probe Data Considering Eddy Diffusion and Oxygen Flux Terms, *GARY R. SWENSON, Aerospace Environment Division, George C. Marshall Space Flight Center, National Aeronautics and Space Administration, Huntsville, Ala.*

The thermosphere diffusion equation used in current static model atmospheres lacks the ability to effectively dictate the constituent distribution in the lower transition region to a mixed atmosphere and neglects other important physical processes. In attempting to take into account these processes, namely eddy diffusion and constituent fluxes, eight thermosphere probe data have been analysed and results are presented here. Of particular interest is the eddy diffusion values required to simulate these conditions and the change in flux direction of molecular and atomic oxygen when the radiation flux becomes zero (i. e. diurnal change in direction). It is further proposed that this process be used in static model development since the equations enable the constituents to be carried to the thermosphere base where a mixed atmosphere exists.

IXA.1 Challenge of Planetary Exploration, *PITT G. THOME, Director, Advanced Programs, Office of Space Science and Applications, NASA Headquarters, Washington, D. C. 20546.*

This paper presents a review of the overall NASA Planetary Program. It discusses the original goals of the program and gives the status of the program to date. An overview of results obtained to date is presented and interpreted in light of the new understanding we have gained of our solar system environment. Today's goals, and current and future programs are discussed. The paper closes with a preview of results expected to be obtained during the 1970's.

IXA.2 Planetary Explorer Program, *P. G. MARCOTTE, Study Manager, Planetary Explorer Study, NASA Goddard Space Flight Center, Greenbelt, Md.*

This paper describes the Planetary Explorer Program which will use Explorer-class spin-stabilized spacecraft and technology developed for the IMP, AIMP, and S3 satellites to study the environments of and perform scientific measurements on the planets Mars and Venus from satellite orbit. Five launches are presently contemplated to Venus in 72, 73 and 75 and to Mars in 73 and 75. An integrated payload of 25-50 lbs. can be accommodated. Details of the mission analysis are presented and the scientific objectives of the mission and possible payload combinations are discussed. The spacecraft and its subsystems are briefly described.

IXA.4 The Viking Project, *JAMES S. MARTIN, JR., Viking Project Manager, National Aeronautics and Space Administration, Langley Research Center, Hampton, Va. 23365, A. THOMAS YOUNG, Viking Science Integration Manager, National Aeronautics and Space Administration, Langley Research Center, Hampton, 23365.*

This paper will discuss the objectives and status of the Viking Project. The prime objective of Viking is to significantly increase our knowledge of Mars with emphasis on information relevant to life. The spacecraft, each consisting of an orbiter and a lander, will be separately launched by Titan/Centaur launch vehicles in mid 1973 for a Mars arrival in early 1974. The spacecraft will be placed into orbit about Mars and the landers will descend from orbit to make soft landings on the planet.

IXA.5 The Pioneer Mission to Jupiter, *HOWARD F. MATTHEWS, Assistant Chief, Systems Engineering Division, NASA Ames Research Center, Moffett Field, Calif. 94035, CHARLES F. HALL, Manager, Pioneer Project, NASA Ames Research Center, Moffett Field, Calif. 94035.*

This paper presents a review of the Pioneer Mission to Jupiter, including the present status of the program. A brief description of the planet Jupiter and a short discussion of the scientific objectives of the mission and the experiment payload selected are given. Detail of a mission analysis for 1972-74 opportunities are presented. A conceptual design of a spacecraft to meet the requirements of the mission is discussed.

IXA.6 Reconnaissance Missions to the Outer Planets, *J. E. LONG, Advanced Planetary Missions Studies Director, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, Calif.*

This paper summarizes a detailed study to determine the preferred system approach, mission requirements and new technology requirements for Jupiter swingby missions to the outer planets, specifically the four-planet Grand Tour. Consideration is given to alternate multi-planet combinations constituting an effective exploration plan for all the outer planets. The depth to which the mission and design requirements were considered in developing alternate system designs is more detailed than in preliminary outer planet mission considerations to date.

IXB.1 Optimum Public Policies for Introducing Transportation Innovations, *ERNEST B. COHEN, General Electric Co., Missiles and Space Division, P. O. Box 8555, Philadelphia, Pa. 19101.*

The overall urban transportation system is partly private and partly in the public domain. Major changes in the public sector must be supported by individual user decisions (model split) in order to be effective. The rate of individual adaption of a new system is governed by a differential equation, containing a rate parameter dependent upon public policy.

Using the calculus of variations and considering all costs and benefits, including rate dependent costs of social dislocation, an optimum introduction curve can be computed. The optimum public policy would program the rate parameter so that the spontaneous adoption rate coincides with the desired optimum rate.

IXB.2 Optimal Container Inventory and Routing, *W. A. HORN, National Bureau of Standards, Washington, D.C. 20234*

This paper shows how to determine optimal container inventories and scheduling for moving containerized mail among stations. The optimization problem is transformed into a network flow problem for which efficient solution methods are known.

IXB.3 Design of Inter-City Ground Transportation Systems, *E. S. DIAMANT, and J. R. VADEBONCOEUR, Systems Group of TRW Inc., 1735 I Street, N.W., Washington, D.C. 20006.*

Classical non-linear programming techniques have been successfully applied to design of new inter-city transportation systems. Mathematical representations were developed which include a description of the physical and performance characteristics of the hardware, system operations, cost and estimates of patronage. The resulting composite model can be analyzed in accordance with a variety of objectives. In each case the solution boundary may be defined by a number of real life constraints such as limited capital, speed restrictions, lane capacity, passenger comfort limits, etc. The programming techniques allow these constraints to be treated both as equalities or inequalities. The design criteria is analytically introduced by the specification of an objective function. Some of these, used to date, include maximization of system patronage, minimization of service costs and maximization of profit or rate of return to the owner/operator.

IXB.4 Railroad Network Simulation Models, *J. N. CETINICH, Southern Pacific Company, 65 Market Street, San Francisco, Calif. 94105.*

The revolution from steam to diesel power provided not only an improved type of locomotion but opened up tremendous potential for greatly improved operations. The more autonomous division structure of operating philosophy has evolved into a systems concept of operations. This demands that a large number of variables be considered with extensive interaction between the variables. It has been extremely difficult to measure the changes of the variables and describe relationships; consequently, many problems in railroad operations have been either dealt with in a very superficial manner or been severely limited in scope. Because most railroads have this common problem, an industry approach has been taken. This paper briefly describes the rationale, structure and intended use of a general railroad network simulation model.

IXC.1 Monopropellant Propulsion for Missile and Space Vehicles, *VICTOR A. MOSELEY, Assistant Manager, Chemical Propulsion Systems Technology Department, TRW Systems, One Space Park, Redondo Beach, Calif.*

This paper deals with current and near-term applications of monopropellant propulsion systems. Basic trade-offs, operational advantages and constraints relevant to hydrazine and hydrazine-based monopropellant systems are presented. Current state-of-the-art and qualified systems are outlined and projected near-term advances are discussed.

IXC.2 SVM-1, 2, and 4 Apogee Motors for Intelsat Communications Satellites, *T. P. BROWNE, Program Manager, SVM-4 Motor Program, Aerojet-General Corporation, Solid Rocket Operations, P.O. Box 1947, Sacramento, Calif.*

This paper presents a summary of development, qualification, and flight results for the small high performance solid rocket motors developed for apogee insertion of the Intelsat series of communications satellites. Particular emphasis is placed on unique requirements for long-life spin-stabilized spacecraft. Historical growth is described from the initial SVM-1 motor used for Intelsat II through the SVM-4 series currently under development for applications in the early 1970's.

IXC.4 The Potential of Low-Cost Launch Systems Using Hybrid Propulsion, *DOUGLAS ORDAHL, United Technology Corp., Sunnyvale, Calif.*

The versatility of hybrid propulsion makes possible the use of unique designs, propellant systems, and materials leading to significantly lower cost for the large boosters projected for use in the 1970's. Exploration of these features leads to projected first stage costs in the range of \$1.10 to \$1.60 per pound of stage for vehicles using boosters in the 3 to 8 million pound thrust class.

IXD.1 Arms Control and National Survival Studies, *RICHARD K. LAURINO, Stanford Research Institute, 1611 N. Kent Street, Arlington, Va. 22209.*

A general reexamination is underway of mathematical models used to evaluate national survival following nuclear exchanges. Present models have provided a systematic basis for policy decisions but have largely ignored many factors important to arms control considerations. The available methodology usually operates on a single value system (usually population). A requirement exists in arms control problems for considering more value systems and for making these values visible in the solutions. Recent work has examined national viability in terms of variety of elements of national strength. Value measures related to various elements of national strength (such as central management, industrial MVA, etc.) have been examined individually and collectively. The inter-relationships of value systems is an area of current research interest involving the use of mathematical programming and related techniques.

IXD.2 The Arms Burden and Political-Economic Development in Latin America, *THOMAS A. BROWN, Department of State, Washington, D. C. 20520.*

A statistical analysis of arms expenditures, economic growth rate, and certain indicators of political maturity for twenty-one Latin American nations over the past twenty years tends to support the notion that the heavier the burden of armaments, the less likely a Latin American nation is to make political or economic progress.

IXE.1 Space Power Requirements for Future Science and Manned Missions, *WILLIAM H. WOODWARD, Director, Space Power and Electric Propulsion Division, OART NASA Headquarters, Washington, D. C. 20546.*

The power system requirements (power level, life, weight, reliability, etc.) for potential future science and manned spacecraft are reviewed. Some indication is given of such possible tradeoffs as power system weight vs. varying ground spacecraft antenna size and data transmission rate. Special factors due to certain mission needs such as low magnetic moments and low charged particle fields are designed and related to space science missions. Systems interface problems relating to power requirements for large manned space stations are introduced.

IXE.2 Solar Cell-Electrochemical Power Supplies—10W to 50 KW, *ARVIN H. SMITH, Chief, Solar and Chemical Power Systems Branch, OART NASA Headquarters, Washington, D.C. 20546.*

Pioneer missions out past Mars, through the asteroid belt and on to Jupiter in the early 1970's will utilize this type power supply. Solar cells, batteries and fuel cells are important

technological options for giant Earth orbiting manned space facilities of the late 1970's and early 1980's. The status and directions of future technological growth for these converters of solar and chemical energy will be discussed in relation to anticipated future needs.

IXE.3 Applications and Development of Space Nuclear Power Systems, JOSEPH D. LaFLEUR, JR., Assistant for Applications and Requirements, Space Electric Power Office, U. S. Atomic Energy Commission, Washington, D. C. 20545.

The National Space Program during the 1970's and early 1980's will include several classes of missions that can benefit greatly from the use of on-board nuclear electric power systems. In several key areas the value of the mission to the space program will depend largely on the use of nuclear power. It is essential that the national program for developing nuclear power technology be planned to attain the required characteristics of these missions. The important mission considerations, the performance objectives derived, and the program to meet these objectives are summarized.

IXE.4 Nuclear Power for Space Exploration—2W to 350 KW, FRED SCHULMAN, Chief, Nuclear Power Systems Branch, OART NASA Headquarters, Washington, D.C. 20546.

Projections for uses of radioisotope thermoelectric generators and status of fuel are reviewed for missions requiring up to 2 KW. Dynamic power conversion systems (Brayton cycle and Rankine cycle) and solid state thermoelectric and thermionic systems are under development for power demands up to 350 KW. Heat sources may be solar collectors, radioisotopes, and/or nuclear reactors. Scheduled availability of these systems is compatible with planned large manned space stations. Development problems and schedules as well as systems aspects are discussed.

IXF.1 PPBS in City, State and County, SELMA J. MUSHKIN, The Urban Institute, 2900 L Street, N.W.; Washington, D.C. 20036.

This paper is addressed to PPB systems application in state, city, and county governments. It summarizes briefly special adaptations of PPB required in these governments, and reviews the current status of implementation with emphasis on interjurisdictional differences in approaches. The potential in strengthening of our federal system by more widespread adoption of processes of improved staff work on behalf of executive decision making is sketched out. And possible next steps are outlined for improving the quality of analytical work and gaining more widespread application.

IXF.2 The PPBS Experience: Progress, Problems, Directions, FRED S. HOFFMAN, J. S. Bureau of the Budget, Executive Office of the President, Washington D.C. 20506

The Planning, Programming and Budgeting System was introduced by the President three years ago. It drew heavily upon the decision-making process developed at the initiative of Secretary McNamara within the Department of Defense. Substantial progress has been made to improve and systematize the analysis and information for decision-making within the largest civilian agencies of the Federal Government, and for many state and local governments. The experience gained, and the problems encountered, indicate needed modifications to apply the Defense model to other agencies, and directions for continued development.

IXG.1 Quality Graphics at 6000 Characters Per Second, ROBERT S. COPE, Vice President, Autographics, Inc., 751 Monterey Pass Road, Monterey Park, Calif. 91754.

This discussion will provide a description of the systems adopted in developing a system designed for the automated preparation of electronic schematics, block diagrams, cabling diagrams and similar engineering documentation, using graphics symbology. It will also discuss the basic approach undertaken in text processing. A system is described wherein engineering graphics, as well as textual documentation, can be maintained and updated on third generation computing equipment and then displayed with graphic arts

quality on a high resolution CRT at up to 6000 characters per second. This discussion will be of a special interest to those faced with the time, money and quality problems associated with engineering documentation.

IXG.2 Current Advances in Computer Graphics, *S. M. MATSA, Manager, IBM N.Y. Scientific Center, 410 East 62nd Street, New York, New York 10021.*

A review of research in the area of three-dimensional displays as well as the discussion of specific applications where computer graphics are being used in a production rather than a research environment.

IXH.1 Observations of Lunar Transient Phenomena (LTP) in the Aristarchus Region, *WINIFRED SAWTELL CAMERON, Goddard Space Flight Center, NASA, Greenbelt, Md. 20771.*

The 346 observations, 175 (Bartlett) and 171 ("all others") were analyzed separately and combined, with four categorical subdivisions in regard to five hypotheses of origin. Categories are (1) gaseous, (2) reddish, (3) bluish, and (4) brightenings. Hypotheses are (1) tidal, (2) sunrise, (3) low-angle illumination, (4) Earth's magnetic tail and/or bow-shock front, and (5) solar activity alone and/or within Earth's magnetic tail.

Correlations varied in descending order with sunrise, magnetic tail, tidal and solar activity, with none for the bow-shock front and are presented in graphical and tabular form. Evidence for relation to internal activity will be presented.

IXH.2 Statistical Geomorphology of the Lunar Surface, *L. B. RONCA and R. R. GREEN, Boeing Scientific Research Laboratories, P. O. Box 3707, Seattle, Wash. 98124.*

A geological model is proposed in which a freshly formed crater is defined as being of class 1. As time progresses, erosional agents will increase the class of the crater to higher numbers. A statistical relationship is shown to exist between the crater class and the crater density. A new method of relatively dating lunar surfaces is developed, which combines the crater density with the degree of erosion, therefore increasing the statistical significance of the results. The surface of the front face of the moon is dated with this method in two different ways. The sequence of formation of the maria and terra regions is presented. It is shown that older areas have higher albedo.

IXH.3 Impact Cratering and Shock Metamorphism as Major Lunar Processes, *NICHOLAS M. SHORT, Goddard Space Flight Center, NASA, Greenbelt, Md. 20771.*

The Orbiter and Surveyor probes provided evidence supporting both impacts and volcanism as causes of primary circular structures and crater depressions on the lunar surface. Impacts, in contrast to volcanic explosions, produce distinctive shock effects in target rocks resulting from pressures of 50–500+ kilobars.

The effects of shock metamorphism from terrestrial meteorite impacts and nuclear explosions will be considered, with special emphasis on changes observed in shocked basalts and other volcanic rocks. The characteristics, distribution, and mechanics of formation of impact structures will also be reviewed.

IXJ.1 Safety Considerations for a High Density Automated Vehicle System, *MICHAEL LENARD, Transportation Systems Division, General Electric Company, 2901 East Lake Road, Erie, Pa. 16501.*

Simulation on the digital computer was used to evaluate systems safety for automatically controlled high density traffic of individually controlled vehicles. Vehicle-borne and wayside emergency control systems were investigated. Sudden failure of a moving vehicle and failure to detect a stalled vehicle ahead were the types of emergencies considered. The number and severity of the resulting collisions were used as the measure of the systems' ability to cope with accidents. System operating characteristics and emergency control response characteristics were the principal parameters explored by the simplified model.

IXJ.2 The Analysis of a T-Type Traffic Intersection Using GERT, *G. E. WHITEHOUSE and C. A. ROTH, Industrial Engineering Dept., Lehigh University, Bethlehem, Pa. 18015.*

A highway exit ramp which provides access to a secondary road through a T-type intersection is analyzed by graphical means using GERT. Automobiles are provided with a single lane up to a point shortly before the actual intersection. At this point the lane widens to permit those vehicles desiring to turn right to separate themselves from the left-turning vehicles. Poisson and Generalized arrival studies are used in the solution process. A critical appraisal of a GERT approach to this type of problem is given.

IXJ.3 Propagation of On-Ramp Density Perturbations On Unidirectional Two- and Three-Lane Freeways, *L. A. PIPES and P. K. MUNJAL, System Development Corporation, 2500 Colorado Avenue, Santa Monica, Calif. 90406.*

Based upon expected value hydrodynamic principles, this paper is an investigation of the effects of on-ramp flow on unidirectional two- and three-lane freeways. This analysis involves the study of the perturbed traffic density on the freeway which has been initiated by the on-ramp flow. The paper then gives the analysis which predicts the propagation of such perturbed densities in space and time and the relaxation distance from the on-ramp where such perturbed densities diminish significantly. The analytical formulation is based upon the primary governing mechanisms which contribute significant effects to the traffic behavior in the vicinity of an on-ramp.

IXJ.4 An Experimental Validation of the Boltzmann-Type Statistical Models for Multi-Lane Traffic Flow, *P. K. MUNJAL and A. V. GAFARIAN, System Development Corp., Santa Monica, California, and J. PAHL, University of California, Los Angeles; Los Angeles, Calif. 90024.*

The Boltzmann-type statistical models for multi-lane traffic flow have been validated experimentally for the time-independent and space-homogeneous case. These validation studies are not limited to any specific functional form of the relaxation time, probability of passing, or the concentration-dependent term given in the adjustment process. This analysis takes the Boltzmann-type equation in its entirety and assesses its ability to describe the results given by the measured experimental data. Speed distribution functions and the flow-concentration relationships are compared with Boltzmann-type statistical models.

IXJ.5 Asymptotic Properties of Delay-Minimizing Schedules, *S. HABER and A. J. GOLDMAN, National Bureau of Standards, U. S. Department of Commerce, Washington, D.C. 20234.*

Customers wishing to go from an origin to a destination arrive during time interval $[0, T]$ at time-varying rate $f(t)$. A given number N of dispatches is scheduled so as to minimize total delay. Various authors have observed that the minimized delay appeared asymptotically proportional to $1/N$. The present paper proves this relationship, evaluates the constant of proportionality, and derives other asymptotic properties of the optimal schedule.

XA.1 High Performance Integrated Space System: The Workhorse of Unmanned Space Exploration, *M. W. HUNTER and J. H. GUILL, Lockheed Missile and Space Company, Sunnyvale, Calif. 90488.*

The paper will present an economical system for conducting a great variety of missions throughout the solar system. The paper will emphasize vehicle performance design and possible missions.

XA.2 Missions to the Comets, *DAVID L. ROBERTS and ALLEN FRIEDLANDER, Astro Sciences Center, IIT Research Inst., 10 West 35th Street, Chicago, Ill. 60616.*

This paper will discuss the scientific objectives, opportunities and mission requirements for

fly-by and rendezvous missions to the comets. Periodic comets having apparitions up to 1986 will be considered.

XA.3 Design of an Advanced Meteoroid Probe of the Asteroid Belt, *SIDNEY L. RUSSAK, Program Manager, Meteoroid Penetration Detector Development, Martin-Marietta Corp., Denver, Colo. 80201.*

Mapping of the meteoroid environment and the penetration hazard through the asteroid belt is a mission that has received renewed interest. The development of detectors for such a mission is discussed as well as some possible designs of spacecraft to be flown on different launch vehicles.

XB.5 Economic Impact on Domestic Air Traffic, An Econometric Approach, *B. R. LIPPKE and J. R. STEWART, The Boeing Company, P.O. Box 707, Renton, Wash. 98055.* without interference and providing better quality

A re-evaluation of classical mathematical approaches to Macro Domestic Traffic Forecasting leaves considerable doubt that any uniqueness can be established for the structural causes of long term growth. This paper introduces alternative approaches emphasizing arbitrary explanations of trend growth, while analyzing shorter term economic effects using econometric techniques. These approaches produce what appears to be unique explanations of short term traffic fluctuations with periods of up to five years as short term effects. Good short term forecasts of traffic are obtained with traffic growth very sensitive to economic conditions. Equally important are inferences which may be drawn relating long term growth to short and long term economic effects.

XC.1 Advanced Chemical Propulsion Systems, *R. R. ATHERTON, Project Manager, Pratt & Whitney Aircraft Division, United Aircraft Corp., West Palm Beach, Fla.*

As future generations of chemical propulsion systems replace those in use today, low cost will become dominant rather than being secondary to technical accomplishments. Booster systems for low cost are taking two forms, as with its specialized requirements for the propulsion system. Low cost through reusability requires systems with low operating cost and long life. The Air Force Reusable Rocket Engine Program is aimed at demonstrating that these goals are achievable. Low cost expendable systems are characterized by low cost achieved by simplicity in both concept and manufacturing technique. The Air Force Minimum Cost Design Booster Program is actively pursuing these goals, as is the NASA Large Solid Rocket Program. In the special engine field, advanced high energy propellants such as fluorine-hydrogen or Flox-methane currently under test may be the least costly approach because these provide very high stage performance.

XC.2 Electric Propulsion Applications, *WILLIAM R. MICHELSEN, Professor of Mechanical Engineering, Colorado State University, Fort Collins, Colo. 80521.*

Electric propulsion has been used for attitude control and orbit adjustment of a number of satellite spacecrafts and can be expected to have further use in the near future. These applications include precision, long-life propulsion functions on satellites, intermediate propulsion for fairly energetic satellite position changes, and primary propulsion for major velocity increment contributions in interplanetary science missions.

Flight-qualified electric propulsion systems and those now under research and development are discussed with reference to present and future space missions where their use is advantageous or practically mandatory.

Future applications of electric propulsion depend greatly on the development of light-weight space powerplants, and progress in this area is summarized.

XC.3 Nuclear Propulsion for Exploration of the Solar System, *J. P. LAYTON, Senior Research Engineer and Lecturer, Dept. of Aerospace and Mechanical Sciences, Princeton University, Princeton, N. J. 08540.*

The usefulness of nuclear propulsion systems in the United States space programs of the future is discussed broadly. Their specific use on missions for exploration of the solar system is developed in some detail. Performance and other, including operational and cost, characteristics of the various nuclear space propulsion systems are presented and comparisons with alternate means of propulsion are made. An analytical approach to the selection of spacecraft and their systems for particular missions as part of an evolving space program is described and its use in guiding research and development activities and in timing of technological readiness is recommended.

XD.1 Strategic Superiority, Deterrence, and Arms Control, *JOSEPH I. COFFEY, Graduate School of Public and International Affairs, University of Pittsburgh, Pittsburgh, Pa. 15213.*

It is frequently argued that American strategic superiority is essential to deter Soviet aggression and to inhibit Soviet risk-taking, to secure U.S. retaliatory forces against technological innovations and uncertainties in weapons calculations, and to reduce damage, should war occur. This paper will examine the feasibility of achieving strategic superiority by various alterations in force postures, will discuss the potential implications for Soviet behavior, and will assess the meaning for arms control of attempts to maintain superiority.

XD.2 Arms Control and Nuclear Safeguards, *FRANK S. HOUCK, United States Arms Control and Disarmament Agency, Washington, D. C. 20451.*

Nuclear safeguards are employed to detect the illegal diversion of fissionable materials. Of arms control concern are international safeguards for detecting such diversions to nuclear weapons programs. The general nature of and requirements for current nuclear safeguards are outlined. The future requirements and arrangements whereby the International Atomic Energy Agency will conduct safeguards inspection for the Non-Proliferation Treaty are summarized. The various research programs underway to improve safeguards techniques and equipments are described with emphasis upon the research of the Arms Control and Disarmament Agency. Three development and testing projects are discussed.

XE.1 The Promise of UHF Satellites for Mobile, Broadcast, and Austere Services, *J. L. HULT, Associate Head, Engineering Sciences Dept., The RAND Corporation, Santa Monica, Calif. 90406.*

Mobile, broadcast, and austere services could be provided by UHF satellites and one-meter diameter Earth antennas by superimposing the downlinks on the current frequency allocations from 450 through 1215 MHz, without interference and providing better quality than conventional service. This newly discovered spectrum (~1500 MHz, if two polarizations are used) could be used for land, marine, and aeronautical mobile services as well as direct broadcast and other austere types of service. This spectrum could be used many times with geographical isolation comparable to conventional terrestrial use, but with greater versatility and capability. Hardware requirements and possibilities are outlined and potential capabilities are described.

XE.2 Antenna Systems for Future Communication Satellites, *W. H. KUMMER, Research and Development Division, Hughes Aircraft Company, Culver City, Calif. 90230.*

As satellite technology advances, more of the burden (size, weight and cost) of the telecommunication link will be shifted from the ground terminals to the satellite itself. Thus, it will be possible to implement smaller and less costly ground and airborne terminals.

A large improvement in system performance can be achieved by an increase in the gain of the satellite antennas. High gain implies a high directivity: a steering mechanism must be

provided for these antennas. Independent communication among scattered Earth terminals via the satellite implies a set of independently steered beams appropriately connected to relay the information.

Various types of possible antennas and arrays suitable for future missions will be discussed. Included will be conventional phased arrays, multi-beam antennas and self-steering arrays.

XE.3 An Experimental Direct TV Broadcast from Satellites, *SAMUEL W. FORDYCE, Manager, Communications and Data Systems, Apollo Applications Program. NASA Headquarters, Washington, D.C. 20546.*

The payload capability of currently available launch vehicles permits consideration of geostationary relays to broadcast TV direct to home receivers.

The increased cost of the large launch vehicles and powerful satellite transmitters can be competitive if sufficient channels can be broadcast over wide enough areas. Such a system appears particularly effective in providing TV to areas currently not served by ground transmitters.

This paper describes two concepts for an experimental payload launched by the Saturn V. These concepts attempt to use this payload capacity to either broadcast a single channel over a wide area as possible, or broadcast as many channels as possible to a more restricted area.

XE.4 Deployment Latch Up Dynamics of an Erectable Truss Antenna, *McLANE DOWNING, Senior Dynamics Engineer, and HAYDEN A. MITCHELL, Dynamics Group Engineer, General Dynamics, Convair Division, San Diego, Cal. 92112.*

Large structures must be densely packaged to fit within launch vehicles and deployed in space. The link-hinge spring powered erectable truss concept is applicable to antenna diameters of 10 to 300 feet. Dynamic analysis must ensure that deployment is reliable, complete, and free from structural damage.

Analysis is based on energy considerations. Geometric constraints are based on observed deployment of antenna models. Dominant latch up loads are due to joint decelerations and link-hinge impacts. Computer programs compute these loads for each of the 109 joints and 276 hinged links, and the associated component stress levels are obtained.

The analysis approach can be applied to 1) structures other than antennae utilizing the erectable truss concept and to 2) other structural design types. Analysis results are the input energy range within which deployment occurs and damage is avoided, and the spring sizing delineated by these results. Analysis iterations are used to minimize weight and optimize design specifics.

This material is new and has not been presented elsewhere except in NASA contractual reports.

XF.2 Plasticity and Conformity in the Application of System Budgeting by State Governments, *ALLEN SCHICK, The Brookings Institution, 1775 Massachusetts Avenue, Washington, D.C. 20036.*

The federal PPBS initiative has spurred many states to adapt PPB forms to their own operations. Although state applications generally are in early stages, it is possible to detect a good deal of variety as well as commonality in state strategies and methodologies. The purpose of the paper is to identify and explain the common and divergent elements in state PPB systems. One of the key factors is whether the PPB initiative has come from planners or from budgeters. An assessment is made of the future course and viability of PPB in the states. PPB is viewed as only one of several possible applications of systems analysis to public resource allocation processes, and alternative applications are examined.

XG.1 Illinois State University Summer Institute in Computer Graphics, *JOE E. TALKINGTON, Associate Professor, Illinois State University, Normal, Ill. 61761.*

Illinois State University has been selected by the U.S. Office of Education for the past three summers to conduct a summer Institute in computer graphics. The major purpose of this program was to upgrade teachers through college level in the most recent developments in this area. The participants learn to use the IBM 1130 Computer, 2250 Display Unit, and CALCOMP Plotter to solve problems of an industrial nature. The students also learn to communicate with a numerical control machine via the computer. Field trips augment the participants' understanding of the critical rate of change taking place in our dynamic technological society.

XG.2 How to Solve Ill-Structured Problems, *F. SELIG, Mobil Research and Development Corporation, Research Department, P.O. Box 900, Dallas, Texas, 75221.*

Conventional use of computers to solve problems pre-supposes a mathematical structure which allows the derivation of a unique answer from the available data and their relationships. Human judgement and intuition are not called upon as part of the solution strategy. This is mainly due to the lack of adequate communication means between man and machine. Computer graphics promises to overcome this hurdle because it provides the techniques to economically convert ideas into objects. After a short description of the current hardware and software situation, specific examples will be given to illustrate how computer graphics can be employed to solve ill-structured problems (model building, forecasting, data interpretation).

XH.1 Lunar Lava Flows, Mare Ridges and Related Features, *ROBERT G. STROM, University of Arizona, Tuscon Arizona, 85721.*

Extensive, identifiable flows cover large areas of the maria. The most well-defined and wide-spread flows occur near the center of Mare Imbrium and cover about 10% of its surface. These flows are of different ages and their margins correspond to slight color differences revealed by infrared and ultraviolet photography. Their morphology, lobate outlines and great areal extent, together with the chemical analyses provided by Surveyor V and VI, indicate that they are lava flows of basaltic composition.

Orbiter photography has revealed the presence of short flows and bulbous extrusions associated with mare ridges.

XH.2 Lunar Volcanism, *JACK GREEN, Douglas Advanced Research Laboratories, Huntington Beach Calif. 92646.*

Major lunar surface features (1 Km in diameter) are thought to be over 95% volcanic in origin. Minor circular features (1 Km in diameter) are probably maars, lava sinks, ebullition craters, volcanic bomb impacts, and other impact craters of a primary or secondary nature. Major or minor elongate or sinuous features are probably all volcanic or tectonic in origin. Large circular basins (200 Km in diameter) both filled and unfilled are considered to be caused by subsidence of an internal origin producing concentric escarpments (Orientalis, Nectaris, etc.)

Surveyor alpha scattering data support the concept of a tholeiitic basalt or basaltic andesite filling the maria and possibly a mix of felsic and mafic pyroclastics in the Tycho rim area.

XH.3 Chemical Composition of the Lunar Surface From the Alpha-Scattering Experiments at Three Surveyor Landing Sites, *ERNEST J. FRANZGROTE, Jet Propulsion Laboratory, 4800 Oak Drive, Pasadena Calif. 91103; JAMES H. PATTERSON, Argonne National Laboratory, 9700 S. Cass Ave., Argonne, Ill. yp439; ANTHONY L. TURKEVICH, University of Chicago, Chicago, Ill. 60637.*

Surveyors V, VI, and VII carried alpha-scattering instruments to obtain chemical analyses of lunar surface material. The chemical composition of each of the samples examined

resembles the average composition of the Earth's crust much more closely than it does that of ultrabasic rocks or chondritic meteorites. The composition of the mare samples (Surveyor V and VI) is similar to that of terrestrial basalts and basaltic achondrites. The agreement of the results of these two mare sites suggests that this basaltic composition is representative of large portions of the surface material of lunar maria. The terra samples (Surveyor VII) contain significantly smaller amounts of elements near iron in mass than do the mare samples.

XJ.1 Recent Developments in Deterministic Inventory Theory, G. D. EPPEN, *University of Chicago, Chicago, Ill. 60637.*

With a brief summary of deterministic models of inventory and production control in the literature as background, recent developments and possible extensions will be discussed.

XJ.2 Recent Developments in Stochastic Inventory Theory, D. INGLEHART, *Stanford University, Palo Alto, Calif. 94305.*

Several of the most interesting recent developments in stochastic inventory theory will be discussed, some open problems will be described, and speculations on the future of the theory will be given.

XJ.3 Min-Max Deterministic Inventory Models, G. WRIGHT and T. IKEDA, *Northwestern University, Evanston Ill. 60201.*

Under the assumption of known demand, this paper discusses the reduction of the determination of minimum cost production and distribution policies for single plant-multiple warehouse systems to min-max optimization problems. Efficient algorithms for calculation of the minimum cost policies are developed.

XJ.4 A Comparison of Economic Lot Size and Minimum Cost Production Methods, D. S. PLYMALE, *Delco Radio Division, General Motors Corp., 700 E. Firmin St., Kokoma, Ind. 46901.*

Examples, based on operating experience, will be presented to illustrate the relative advantages and disadvantages of these two methods of controlling the inventory of finished items.

XJ.5 An Empirical Study of Some Multiproduct Inventory Problems, A. C. WHEELER and J. T. WITHERSPOON, *Washington University, St. Louis, N.Y. 63130.*

This paper treats, for a variety of cost functions and demand distributions, finite-horizon two-product stochastic inventory problems involving periodic review and setup costs. Characterization of the optimal policy, computational difficulties, and usefulness of the results in analyzing problems of larger scale are discussed.

XJ.6 Seasonal Demand in Multiple Item Inventories, J. R. GILLESPIE, *Research Laboratories, General Motors Corp., Warren, Mich. 48090.*

In a multiple item inventory system, one item may be capable of meeting part of the demand for another item. This paper discusses optimal policies in the face of such partial substitutability particularly in cases where demand is strongly seasonal.

XIA.2 Detection and Identification of Organic Compounds On Other Planets, K. BIEMANN, *Massachusetts Institute of Technology, Cambridge, Mass. 02139.*

A more than cursory knowledge of the organic compounds present—if any—on other planets is necessary to evaluate the possibility of past, present or future occurrence of biological phenomena. Our thoughts concerning the origin of life on Earth could find support or modification if one would know the state of organic chemistry on other planets.

The methods that can be used to detect organic compounds by remotely controlled or pre-programmed experiments are of two kinds: Those designed to detect specific

compounds, selected on the basis of certain reasons, such as their importance in terrestrial life and those that are non-specific, capable of detecting and identifying a broad spectrum of compounds regardless of their relationship to terrestrial life.

Experiments presently planned for future Mars—Landers will be discussed in an effort to outline these approaches and the kind of results they might be capable of yielding.

XIB.1 The Coming Information Explosion, *HOWARD J. HILTON, Professor Social Science and Economics, The Pennsylvania State University, Middleton, Pa. 17057.*

With the growth and interdependence of countries, the expansion of communications by satellite, and the development of vast computer networks, the need for unique identification of all recorded knowledge and information will become imperative. It is, in fact, essential today as a means of organizing, storing, and retrieving information. This paper discusses approaches to the problem and outlines a code designed for international use. This code can be applied to complete works or bits of information with the assurance that its designation will be unique and capable of following the information as it moves from medium to medium, i.e. hardcopy, computer cell or disc, microimage, magnetic tape, cathode ray tube, or hardcopy printout.

XIB.2 A Matrix Approach to Management Information System Design, *C. S. HWA, Director, CompuSys Inc., Albuquerque, New Mexico 87112.*

The identification of (1) the relationship of various information, (2) the flow of this information within a system, and (3) the structure for storing this information are the major tasks involved in the design of a Management Information System (MIS). A concept of matrix analysis is introduced in this paper to facilitate these tasks. The concept involves the use of an input matrix, a structure matrix, and an output matrix. The input matrix is formulated to identify the source of the information while the output matrix is formulated to identify the retrieval requirements of this information. Through matrix manipulation, a structure matrix can be generated which identifies the input/output relationship of the MIS. By examining the property of the structure matrix, the property of the data base within the MIS can also be identified.

XIB.3 Ultrafiche and its Application to Colleges and Universities, *JAMES P. KOTTENSTETTE, Research Engineer, Denver Research Institute, 2199 South University Boulevard, Denver, Colo. 80210.*

Development of the ultrafiche system with its ability to reproduce more than 3,000 pages of printed material on a 4" x 5" film card and provide a high quality reproducible image on a reader represents an advance in the production, storage dissemination and use of printed material. The social and economic consequences of this technology can have a major impact upon the educational and library systems of the nation. It is one of the purposes of this study to identify and investigate in a systematic way the critical parameters of an ultrafiche system to relate these parameters to library requirements and cost constraint and to thereby arrive at recommendations for ultrafiche publication. These parameters include economic factors, technical factors of reader design and document reproduction and human factors governed by the intended use of the readers.

XIB.4 Coming Information Explosion: Information Storage Models, *FERDINAND F. LEIMKUHLER, Univ. of Calif., Berkeley 94720.*

The stochastic nature of short-run demands for information services and the long-run decline in the usefulness of stored information are singled as crucial elements in the effective design of library-type information systems. Analytic models which combine these processes with the exponential growth of new information are developed for the purpose of deriving meaningful design rules for inventories. A special effort is made to confine attention to those models which are of fundamental importance, and which exhibit the properties of analytic simplicity and empirical robustness, so as to form a basis for future experiments and development.

XIC.1 Status of Current Upper Stages, *STANLEY A. GREENE, Director Advanced Development, Titan III Directorate, Vehicle Systems Division, Aerospace Corporation, El Segundo, Calif.*

A description of the three upper stages (Centaur, Transtage, and Ascent Agena) utilized by DOD and NASA will be given. Their performance with various lower stages and mission capabilities will be discussed. Finally, their capability for growth in terms of mission capability and performance will be outlined.

XIC.2 NASA Space Program Possibilities and Upper Stage Implications, *BERNARD MAGGIN, Technical Program Officer, Office of Program Plans and Analysis, NASA Headquarters, Washington, D.C.*

An outline of the kinds of missions being considered by NASA for the 1970's will be reviewed. Some thoughts on program concepts beyond this time period will be noted. The implications of these manned and unmanned mission concepts on L/V upper stages will be discussed. Some comments will be made regarding needs for new systems, and their performance and design requirements.

XID.1 Results and Directions in n-Person Cooperative Games, *WILLIAM F. LUCAS, The Rand Corporation, 1700 Main Street, Santa Monica, Calif. 90466.*

Some recent results and some major unsolved problems in the theory of stable sets (von Neumann-Morgenstern solutions) and the theory of the core for n-person cooperative games in characteristic function form, generalized characteristic function form, and partition function form will be discussed.

XID.2 An Example in the Theory of Differential Games, *JAMES H. CASE, Mathematics Research Center, U. S. Army, University of Wisconsin, Madison, Wis. 53706.*

The problem of revenue maximization for two competing firms manufacturing like goods is cast as a differential game. The qualitative aspects of the equilibrium point solution of the game are then discussed with the aid of some results of ordinary differential equations.

XID.3 Lagrange Multiplier Solutions to Constrained Matrix Games, *ALAN I. PENN, Lambda Corporation, 1501 Wilson Blvd., Arlington, Va. 22209.*

A general methodology is presented for the solution of constrained matrix games. The usual context is the optimal allocation of constrained resources by two opposing sides among a series of independent cells such that the payoff overall is the sum of the payoffs at each cell. A sample problem is discussed where the ensemble of matrix games is transformed into a sequence of unconstrained matrix games by the introduction of generalized Lagrange multipliers in each payoff matrix. A rigorous solution to the original problem is obtained by solving the unconstrained games.

XID.4 Solving Classes of Infinite Games by Linear Programming, *TIMOTHY W. RUEFLI, Department of Management, University of Texas, Austin, Texas 78712.*

Infinite games with separable payoff kernels can be regarded as finite convex games. Some classes of games with this property are S-games, convex games, and an important class of games over the unit square. Solutions to these classes of games can be found by the fixed point method or the method of dual cones. This paper shows that such complexity is not necessary, because solutions to such games can be found using some linear programming techniques. In addition to providing a simple algorithmic method for obtaining solutions, linear programming provides a theoretical context for characterizing these solutions.

XIE.1 A Systems Approach to Data Management, *JOSEPH C. HELLAND, Manager of Data Management Systems, McDonnell-Douglas Astronautics Company, Western Division, Huntington Beach, Calif. 91547.*

In the design of complex satellite data management systems, many different and sometimes contradictory aspects must be considered. Among these factors are the users requirements

for information derived from the experiment, the characteristics of the data generated by the sensor, and constraints imposed by the satellite configuration, such as weight and power. In a complete systems design, allocation of data processing functions between the vehicle and the ground will be influenced by the available communication facilities. This paper discusses the interaction between these and other significant influences on the design of satellite data management systems.

XIE.2 Onboard Data—Management Systems, *JAMES F. HUGHES, Chief of Checkout Branch, NASA Manned Spacecraft Center, Houston, Texas 77058.*

A space station will produce large quantities of mission-critical operational and experimental data which must be either telemetered to the ground in real time or processed and retained on board the space station for evaluation and relayed to Earth later.

The methods of telemetering data to the ground which were utilized on the Mercury, Gemini, and Apollo programs and which were planned for the Apollo Applications Program are not adequate for future expanded data loads. The NASA Manned Space Flight Network cannot be expected to continuously monitor the space station systems and payloads. This means that a large portion of the data must be handled operationally on board the station.

XIE.3 Automatic Maintenance Aspects of Data Processing in Unmanned Spacecraft, *ALGIRDAS AVIZIENIS and DAVID A. RENNELS, Jet Propulsion Laboratory, Pasadena, Calif. 91103.*

The unmanned exploration of the solar system requires voyages of several years' duration. The success of a mission depends on the survival and proper functioning of the data collection and processing system at the end of the voyage. Automatic maintenance (fault detection and repair) can be incorporated into the spacecraft to raise the probability of proper operation at arrival. The methods of automatic maintenance are presented and illustrated by discussion of the JPL STAR *SELF-TESTING-AND-REPAIRING* spacecraft digital computer. The STAR methods are also applicable to raise the reliability of ground-based real time computers in critical applications: high-speed transportation, automated hospitals, etc.

XIF.1 Applications of Cost-Benefit Analysis to Federal Manpower Programs, *LILLIAN REGELSON, Office of Economic Opportunity, Executive Office of the President, Washington, D.C. 20506*

The expenditure of federal funds for non-defense manpower programs has increased from \$403,000,000 in 1964 to an estimated \$2.441 billion in 1969. Benefit-cost analysis has been applied to some of the problems accompanying this rapid growth. The analyses which have been performed have been severely limited in both methodology and quality of the available data. Even so, they have provided some useful insights into the manpower programs and the potentials and limitations of benefit-cost analysis. The applicability of the results should improve further as evaluation programs now underway develop new methodology and generate better data.

XIF.2 An Experimental Approach to Program Analysis: Step Child in the Social Sciences? *WORTH BATEMAN, Deputy Assistant Secretary, Office of Planning and Evaluation, Dept. of Health, Education and Welfare, 330 Independence Avenue S.W., Washington, D.C. 20201.*

The paper will discuss the limitations of non-experimental data in analyzing the cost/effectiveness of Government programs. It will show how the two most frequently used sources of data for analysis—sample surveys and program reporting systems—have left unanswered or answered in an unsatisfactory way the key policy issues in a number of social programs—income maintenance, health, education, and manpower training. The paper will argue that an experimental approach to program analysis closes most of the gap

which now exists between the data desired by policy makers and the data available to policy makers. The extremely limited efforts currently being made in this area will be documented and some reasons why this is so will be offered.

XIG.1 Energy Utilization and Aid Effectiveness in Nonmechanized Agriculture: A Computer Simulation of a Socioeconomic System, *DOUGLAS DAETZ, Engineering Specialist, Advanced Systems Dept., Systems Analysis Laboratory, Sylvania Electronic Systems—Western Division, P. O. Box 205, Mountain View, Calif. 94040.*

The problem of evaluating the effectiveness of aid given to an agricultural society is addressed. A new approach to this problem, combining systems analysis and computer simulation techniques, is used to study the effectiveness over time of several aid programs, including medical, food, education, and family-planning aid. For the first time a comprehensive, closed-loop model exists which quantitatively supports the hypotheses of major investigators in the field of economic development that aid without population control can be only temporarily effective and that a threshold exists below which aid will not stimulate self-sustaining economic growth.

XIG.2 A Control System Excitation-Response Model for Import-Proportion in a National Economy, *P. S. SATSANGI, Dept. of Electrical Engineering, S. S. SENGUPTA, Dept. of Economics, J. B. ELLIS, Dept. of Electrical Engineering, University of Waterloo, Waterloo, Ontario.*

The objective of the analysis is to present a testable control system model of the processes determining the fraction of total inputs into a national economy accounted for by imported inputs. Although such processes are complex, they are of prime importance in long term stability studies of national balance of payments. It is observed that the proportion of imported inputs to total inputs will be determined primarily by the state of production capacity on the one hand and by the dynamics of the domestic price level, on the other hand.

XIG.3 The Application of Taylor's Theorem in Obtaining the Probability Distribution of Long-Range Profit, *DENNIS E. SMITH, HRB-Singer, Inc. State College, Pa. 16802.* Although the functional relationship between LRP and its various components is usually well-defined, the difficulty of determining the probability distribution of LRP prevents an immediate answer to a question such as "What are the chances that the LRP associated with decision D will exceed X dollars?" In a situation such as this, the first thought is to use Monte Carlo (i.e., random sampling) in order to provide an approximation to the distribution of LRP. The advantages and disadvantages of an alternative approach, the use of error propagation formulas based on a Taylor series expansion, is discussed.

XIG.4 Significance of Changing Technology and Economics for the Distribution Company of the Future, *R. A. HAMMOND, McKinsey & Company, Inc., 245 Park Ave., New York, N. Y. 10017.*

Many significant technological and economic changes are taking place in the transportation industry which may lead to a new type of distribution company in the future. The container revolution, based on the economics of shipping standard size boxes on special container ships through high productivity ports, is now beginning to have an impact on both inland and overseas traffic.

Enormous opportunities exist for building totally new distribution systems and services. To develop them, companies require imaginative in-depth analytical and action steps. This paper discusses the significance of the emerging changes, and some of the opportunities and approaches to accomplish them.

XIH.1 Mechanical Properties of Lunar Soil, *RONALD F. SCOTT, California Institute of Technology, Pasadena Calif. 91103.*

Detailed analyses and post-flight terrestrial simulations have been made of the lunar soil

tests performed by the Surface Sampler on Surveyor spacecraft 3 and 7. Tests have been made to determine the behavior of selected soils with varying density, cohesion and friction angle. The effect of lunar gravity on the soil behavior has been examined. The paper describes and presents the results of the tests.

XIH.2 Deposition of Comets and Interplanetary Debris on the Lunar Surface, *DAVID B. BEARD, University of Kansas, Lawrence, Kansas 66044.*

The evidence for the numerical density, size, and spatial distribution of interplanetary dust will be reviewed. Possibilities for the gravitational concentration of this material on more massive objects in the solar system, e.g., planets and satellites, will be discussed. Recent calculations and interpretations of experimental balloon based observations will be discussed the further evidence they give on the limiting size and specific gravity of interplanetary dust. The size distribution and chemical composition of comets will be discussed as well as the frequency and some effects of their impact on the lunar surface.

XIH.3 The Lunar and Cislunar Environment, *JAMES F. KENNEY, Boeing Scientific Research Laboratories, P. O. Box 3981, Seattle Wash. 98124.*

The radiation encountered on a lunar mission depends on several factors such as the level of solar activity and the trajectory and duration of the mission. In a low altitude Earth orbit, the spacecraft is well shielded by the Earth's magnetic field, but the absence of an appreciable lunar magnetic field eliminates that protection near the moon. High dose rates are encountered during passage through the Earth's trapped radiation belts, but the short transit time results in a low total dose. The normal solar and galactic cosmic radiation does not present any appreciable mission constraints. Major solar flare events can generate potentially dangerous particle fluxes, but a warning and prediction system is in operation to minimize this hazard. The expected radiation environment will be described.

XIJ.1 Canal Lock Simulation, *GEORGE F. WIGGERS, Department of Transportation, Washington, D.C. 20590*

A simulation model has been developed for canal operations based on a special study by the Department of Transportation of the Saint Lawrence Seaway.

XIJ.2 The Simulation of Intercity Travel Demands, *P. M. PEARSON, Department of Civil Engineering, University of Waterloo, Waterloo, Ontario.*

It is the objective of this paper to demonstrate the application of systems theory to the demand for travel in the Windsor to Montreal corridor. The components of the system include measures of the origin city generators, the intrinsic parameters of the travel links and the measures of the attraction of the destination cities. The model is verified with actual data from the Windsor to Montreal corridor. Specifically, the anticipated changes in demand on a public carrier, due to changes in price, changes in seats offered and changes in schedule are derived. Further, the planner in deriving the consequences of a particular policy can examine all affected modes in a particular subsystem.

XIJ.3 Temporal Expansion of a Transportation Network, *S. C. FREY and G. L. NEMHAUSER, Department of Operations Research and Industrial Engineering, Johns Hopkins University, Baltimore, Md. 21218.*

Models are developed and solution techniques are proposed for the expansion of a transportation network over time. The controllable variables are the arc capacities, which measure the arc's ability to satisfy the demands placed on it. Four costs are considered: (1) a cost of capacity expansion, (2) an operating cost, (3) a social cost of congestion, and (4) a cost dependent on the number of potential travelers discouraged from using the system. A practical algorithm for large networks is given for the case in which the usage function and all costs are linear. Various properties of the solution are presented for the non-linear case.

XIJ.4 Economic Analysis of Air Eligibility of Military Overseas Shipments in Peacetime, R. D. GOODFRIEND, Research Analysis Corp., McLean, Va. 22101.

This paper presents selected results of a two-year study that applied a computer-programmed version of the total - distribution - cost method of economic analysis to predict peacetime airlift and sealift demand in the military establishment. Commodities suitable for overseas shipment by air were selected on the basis of economic eligibility rather than priority need, a criterion useful only under peacetime conditions. The results of the study are considered useful not only to the military sponsor but to commercial firms interested in the increase in demand for air eligible shipments that may occur with reductions in the air ton-mile rate expected with the introduction of larger freight aircraft.

XIJ.5 The Application of OR to Stop Selection and Sequencing For the Aeromedical Evacuation Problem, T. E. KOWALSKY, J. GRIFFIN, and G. M. CUSACK, U.S.A.F., Headquarters M.A.C., Command Operations Analysis, Scott A.F.B., Ill. 62225.

The Aeromedical Airlift System is shown to be a special case of the transportation problem. Unlike scheduled airlines, the Aeromedical Airlift System does not fly fixed routes. A heuristic algorithm is developed which first ranks the stops according to certain quantitative rules and then selects the highest ranked stop. This stop is then sequenced with previously chosen stops by a branch and bound algorithm that checks all constraints. The program returns to rerank the stops and continues until all stops are added or no further stops can be added.

XIIA.1 Accessible Regions Beyond the Solar System, MAXWELL W. HUNTER, Director Advanced Space Program, Space Systems Division, Lockheed Missiles and Space Co., Sunnyvale, Calif.

The accessible regions of our galaxy are defined in this paper by ease of access in terms of human convenience. The region near the solar system which can be reached within a human lifetime by means of relatively straight forward propulsion systems is seen to extend to about 500 A.U. The region which could be reached, again within a human lifetime but using the theoretical characteristics of advanced propulsion systems which do not violate currently accepted physical laws, could extend to about 20 light years. The rest of the galaxy would require some sort of time dilation. The impact of physical vs. biological time dilation is discussed.

XIIA.2 Evolution of Interstellar Operations, KRAFFT EHRLICHE, Chief Scientific Advisor Advanced Programs, Space Division, North American Rockwell Corp. Downey, Calif.

Time and space make interstellar operations the concern of a different civilization and technology. This does not mean star flight lies in a distant future because their outlooks and capabilities change and progress rapidly. The step wise evolution of interstellar operations is described based on several scenarios. Beginning with ultraplanetary probes in this century, the scientific objective and technological approaches to unmanned interstellar flight are described. For manned interstellar operations, the potential incentives are discussed. A new approach to analyzing the occurrence and nature of alien intelligences is presented. In absence of incentive by alien civilizations, the scientific, technological and social/cultural factors driving the evolution of operations beyond the solar system are discussed.

XIIA.3 Interstellar Travel, A Round Trip Propulsion System With Relativistic Velocity Capabilities, PHILIP NOREM, Director, Engineering, Peninsula Research and Development, Fort Erie, Ontario, Canada.

An overall system employing a vehicle with a solar sail, a large laser array, and employing interactions with the interstellar magnetic field for changes of vehicle direction is shown capable of round trip interstellar travel with presently known technology. Round trip journeys of 75 to 150 years are shown to be reasonable for 1,000 ton payloads with several

years spent exploring the target planet. The overall system is new, though some components have been separately discussed.

XIIB.1 Investment in Natural and Human Resources, *JOHN M. KING, Chairman, Board of Directors, King Resources Company, Denver, Colo. 80202.*

There are all kinds of natural resources, just as there are all kinds of people, but they all have several things in common: They are on the Earth, or in the Earth awaiting intelligent development; they are useful, they are needed by mankind and they are valuable.

Since there are so many kinds of natural resources the approach to investment in them is a matter for the professional expertise of the money managers who have an obligation to carefully explore the field and spell out both the rewards and the risks involved. And there are always both. The old saying "Nothing risked, nothing gained" holds true in natural resources as well as in other fields of investment. But risk need not be blindly or foolishly taken.

XIIB.2 Improving the Analysis of Water Resources, *IRA A. WATSON, Chief, Economics Branch, Division of Economic Planning, Federal Center, Denver, Colo. 80225.*

Rapid and flexible analytical methods are essential to planning natural resource development in a context of continual change in social and technological conditions. The optimizing methods of operations research and the procedures of systems analysis stimulate more explicit treatment of data and permit consideration of more alternatives in planning development and management of water resources. Much remains to be done in specifying objectives and in broadening the analytical structure to recognize non-monetary aspects of decisions for water programs.

XIIB.3 Participating in the Growth of Emerging Economics, *HAL S. DYNAN, Vice President, Corporate Planning, Chase-Manhattan National Bank, New York.*

The progress of world economics is related to the growth of all countries. The successful growth of the emerging countries is particularly essential to the economic and social stabilizing of world affairs. The private sectors of the developed countries need to participate in the resource development of the emerging countries.

XIIC.1 Reusable Launch Vehicle Concepts, *EUGENE LOVE, Assistant Chief, Aerophysics Division, National Aeronautics and Space Administration, Langley Research Center, Hampton, Va. 23365.*

A survey of current and anticipated reusable launch vehicles is made, with the added consideration of technologies required to bring such vehicles into reality.

XIIC.2 Low Cost Boosters, *DONALD M. ROSS, Acting Director, AF Rocket Propulsion Laboratory, Edwards Air Force Base, Calif. 93523.*

This paper presents a design and management concept for substantially reducing development and recurring costs of space launch vehicles. Progress is reported on the technology phase of the Air Force's development programs. Goals for recurring costs are specified together with engineering and management approaches for meeting these goals. The presentation concentrates mainly on the development of pressure-fed, liquid propellant rocket for meeting program objectives. The management aspects relate to fundamentals essential to meeting the reduced costs and show which are in consonance with DOD and Air Force policies.

XIIC.3 Simplified Low Cost Expendable Vehicles, *DAN DRISCOLL, Manager, Low Cost Launch Vehicle Task Team, National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville Ala. 35812.*

A survey of current and anticipated simplified, low cost, expendable launch vehicles is

made, with the added consideration of technologies required to bring such vehicles into reality.

XIIC.4 Use of Multiple Outlets for Reducing the Effects of Stratification on Propellant Supply Temperature Variations, R. J. SCHOENHALS and E. R. F. WINTER, *School of Mechanical Engineering, Purdue U., Lafayette, Ind. 47097, and R. N. NELSON, US Navy.*

Heat transfer to the fuel or oxidizer of a liquid fuel rocket produces thermal stratification, the condition resulting when the heated portion of the liquid in a supply tank rises to the top of the vessel because of its buoyancy. The undesirable effects of stratification on liquid propellant systems are well known. Among these is the non-uniform temperature of the propellant as it flows from the supply tank during engine burning. Such a temperature rise increases the probability of occurrence of cavitation, drastically reduced supply rates, and premature engine burn-out before full utilization of the entire fuel supply has been achieved. Various methods for reducing the effects of stratification have been studied previously, and each of these possesses some disadvantages in terms of possible increases in cost, weight, power requirements, complexity, or unreliability. The present paper describes a new technique for reducing the propellant supply temperature rise during drainage from the supply tank. Multiple outlets are employed which feed into a mixing chamber at the lower end of the supply tank.

XIID.1 Why People Play Games—Report of a Survey, CLAYTON J. THOMAS, *Assistant for Research, and GERALD M. McNICHOLS, Operations Analyst, Operations Analysis, Office, Vice Chief of Staff, HQ USAF, Washington, D.C. 20330.*

A decade ago one of the authors participated in a survey of gaming activities, which produced examples, rationale, and views of what the sixties would bring. We have recently contacted some of the respondents to that earlier survey, and other gamers, to elicit current views. This paper reports some of the changes made in the past ten years, both in techniques of gaming and in the emphasis given to various areas of application. It also summarizes some predictions for gaming in the seventies.

XIID.2 Experimental Uses of the Political Military Exercise, JOHN D. STEINBRUNER, *Assistant Professor of Political Science, Massachusetts Institute of Technology, Cambridge, Mass. 02139.*

The paper discusses the development of the political-military exercise (PME) as a tool for research. The paper argues that in the evolution of the PME it has become clear that there are a number of alternative uses and that the choice of the research objective strongly affects the specific game design.

This paper will report on recent work with the PME on basic problems of foreign policy decision-making and will assess some of its advantages and disadvantages in the light of this experience.

XIID.3 Trends in Military Gaming, MILTON G. WEINER, *The Rand Corporation, Santa Monica, Calif. 90406.*

This discussion will highlight several trends in military gaming. Among these is the trend toward increased use of computing machinery as indicated in a sample of 79 games of which only five involved human players. Trends in the use of scenarios indicate less systematic use of a broad context and greater use of explicit factors which imply a scenario. The use of human players shows trends toward narrowing the range of strategic considerations, increasing the number of tactical variations, and increasing the amount of automated bookkeeping. The trend toward using games for analyses of selective aspects of military operations rather than for establishing conflict outcomes is also discussed.

XIID.4 Computer Time Sharing in Business Gaming, *F. WARREN McFARLAN, Assistant Professor of Business Administration, Harvard University, Cambridge, Mass. 02138.* This paper discusses the current role computer time sharing plays in Business Gaming Activities at the Harvard Business School. Two types of use will be described.

1. Its use as an enabling device for implementation of models designed to ease certain types of appropriate but complex analysis in a Batch-oriented business game.
2. Its use in a Business Game designed for time sharing.

The teaching objectives and problems associated with each use will be identified and described.

XIID.5 Some Elementary Bargaining Models, *BEN T. RHODES, SR., Assistant Professor of Industrial Engineering, University of Houston, Houston, Texas 77004.*

Presented are models for two-party (labor management) and three-party (labor-management-government) bargaining situations. The models covered are contract value models (which are concerned with potential contracts) and attitude models (which are concerned with strategies and tactics).

The models are quantitative in nature, but certain inputs are necessarily value judgments of the parties involved. Certain concepts such as a contract partition and resistance points are defined. A discussion of the way models can be used to improve bargaining procedures is included.

XIIE.1 Flight Evaluation of Radar-Inertial Systems, *RICHARD J. HAYES, NASA Electronics Research Center, Cambridge, Mass. 02139.*

The NASA-ERC program for the development of guidance, navigation, and flight control technology for aircraft is reviewed in this paper. It describes the technical approach which includes in-flight evaluation of radio-inertial hybrid systems based initially on helicopter flight tests at Wallops Station, Virginia. It also describes future plans for development and evaluation of advanced navigation and control systems and components.

Initial flight tests results of a radar-updated Gemini inertial navigation system during the approach and landing phase are presented. These results describe a range of performance based on deliberate variations of the system up-date and inertial system performance parameters. As such it provides the beginnings of a body of test data and experimentally verified analytical models to support the specifications of future navigation and control system designs.

XIIE.2 Low Cost Inertial Navigation, *WILLIAM J. WHITESELL, Chief, Astronautics and Computer Science Laboratory, U. S. Air Force Academy, Colo. 80840.*

During the early 1960's the Air Force Systems Command expressed concern over the excessive cost of development and operation of aircraft inertial navigation systems. To emphasize this concern, an in-house development group, Detachment No. 1, A.F. Avionics Laboratory, was established at Holloman AFB. The goal of this group was the design, development and integration of a low cost, reliable inertial guidance system. The resulting system, the Locating system, represents a composite of hardware from throughout the inertial industry. Final system integration was accomplished in-house by AFSC Military/Civilian engineers. The Locating system started flight test at the Central Inertial Guidance Facility at Holloman on 5 July 1968 and ended with a delivery flight to the Air Force Academy on 10 January 1969.

XIII.E.3 Guidance Scheme for Low Thrust Parabolic Insertion, *ROREN A. SCHULTZ, Senior Scientist, Space Division, The Boeing Company, Huntsville, Ala. 35812; STEVE S. HU, Director of Research Analysis, Department of Navigation, Northrop Electronics Division, Hawthorne, Calif. 90250.*

This paper is intended to present a technique for adapting the range limited iterative guidance scheme to the multi-revolution trajectory with a low thrust propulsion system. The guidance efforts for commanding and directing the vehicle along a desired spiral flight path are described. In addition, alternative guidance schemes are analyzed and discussed. The advantages of the low thrust guidance scheme over the high thrust guidance scheme also are discussed.

XIII.E.4 Simplified Performance Analysis of Space and Missile Guidance, *JOHN T. WAGNER and DONALD F. McALLISTER, TRW Systems, Redondo Beach, Calif. 90406.*

This paper describes an approach for automatically generating sensitivities of space mission performance with respect to error sources directly from the output of a master Monte Carlo simulation. The error sources entail guidance instrumentation, orbit determination, vehicle propulsion, deployment, environmental, and modeling errors or uncertainties. In this manner the effect of new trajectories, navigation, sensor, and propulsion error models, or changes to the mission targeting and event sequencing on the mission performance can be readily and economically ascertained. Formulae are presented for hand (or small scale computer) evaluation of error budgets (and modeling confidence) and prediction of mission performance on a deterministic or statistical basis.

XIII.E.5 Navigation for Surface and Aerospace Vehicles by a Very Low Frequency Radio Network *H. W. TURNEY, JR., Deputy Director, Radio Navigation Systems Lab. Northrop Electronics Division, 2301 West 120th Street, Hawthorne, Calif. 90250.*

The fundamental concept of phase measurement of very low frequency radio waves for navigation is studied and analyzed. This radio navigation network is called OMEGA. This paper presents a summary of the OMEGA operational concept, how it can be used for various applications, and the status of the total system development. The organization format consists of (a) a generalized discussion of the system and the performance, (b) details of the operation, (c) discussion of error sources and their impact on the user, and (d) presentation of various potential applications ranging from slow moving to high performance vehicles.

XIII.E.6 Contribution of Navigation Analysis of Onboard Systems to Mission Planning in the 70's, *JAMES L. KNOEDLER, Head, Navigation Analysis Section, Systems Evaluation Department, TRW Systems Group, Houston, Texas 77058.*

The accuracy with which trajectory state vectors can be determined from navigation data is of major concern to mission planners. New techniques developed during the Apollo mission analyses can be extended and applied to planning missions of the 1970's. The use of onboard navigational systems as back up and prime systems require nearly optimal navigation plans. Since the use of onboard measurements taken on manned missions is quite new, the techniques developed are near the limit of the state of the art. The navigation plan guidelines and error analyses on the Apollo missions have shown that onboard data is adequate for accurate navigation.

XIII.E.7 Optimal Attitude Control System for Spinning Aerospace Vehicles, *V. S. SOHONI and D. R. GUILD, Staff Engineers, Department KO4, IBM Corp., Huntsville, Ala. 35812.*

The paper describes an original application of modern control theory and optimal control techniques to develop practical design methods for the attitude control system of a spinning aerospace vehicle. The Pontriagin maximum principle is used to obtain an optimum control policy for the linearized model representing the spacecraft dynamics.

Two principal improvements in the solution are: (1) an efficient integration algorithm for the state, costate, and variational equations, and (2) a multidimensional zero-finding algorithm that does not require a good initial guess of the costate variables.

This paper further demonstrates how the approach outlined above is applied in a design situation to derive different optimal controllers.

XIIF.1 The Status of Methods in Cost-Effectiveness Studies of Social Action Programs, *ROBINSON HOLLISTER, Prof. Institute for Research on Poverty, University of Wisconsin, Department of Economics, University of Wisconsin, Madison, Wis.*

Contrasts are made between the tasks undertaken in cost-effectiveness studies in defense and water resources, on the one hand, and social action (largely poverty) programs on the other. The differences in tasks have generated a new set of methodological problems. Problems discussed are: the setting of objectives, the use of control groups, the trade-off between sample size and improved measurement quality, proxy measures for long term effects, measurement of "community effects." The importance of consideration of the "replicability criterion" in designing cost-effectiveness studies is stressed. The over-riding importance of organizational problems in execution of studies of social action programs is highlighted. Finally, suggestions are made concerning the development of reasonable criteria for acceptance or rejection of cost-effectiveness studies and a new strategy for development of better evaluations of social action programs.

XIIG.1 Decade Forecasting Methodology Based Upon Information Progression, *J. C. HOAGLAND, Digital Systems Manager, and G. E. SMITH, Engineer Scientist, McDonnell Douglas Astronautics Company, Western Division, 5301 Bolsa Avenue, Huntington Beach, Calif. 92467.*

A "top-down" technique is presented for forecasting requirements a decade into the future based upon information and information progression rather than the hardware or experimental approach. The forcing functions for expansion of any society are the demands placed upon the macrosystem by its informational needs. (Macrosystem: A conglomerate of subsystems, people, equipment and resources which must be assembled and operated before specific, determinable national, business or social objectives can be met.) The analysis proceeds from the macrosystem goals. The technique evaluates the goals as to realism and achievability and establishes the necessary informational matrix for each system level and time phase.

XIIG.2 Forecasting by Trend Extrapolation, *T. I. MONAHAN, Long Range Planning and Technological Forecasting, Naval Applied Science Lab., Flushing and Washington Avenues, Brooklyn, N.Y. 11251.*

This paper describes the method of technological forecasting by trend extrapolation, which assumes that whatever has happened in the past will continue to happen in the future, provided there are no major disturbances. The extrapolation of time-series-related trends can vary from a simple continuation of an existing trend, to the use of mathematical methods of curve fitting, and finally to trend extrapolation with judgement modification based on consideration of causative factors.

XIIG.3 Opinion Technology, *N. C. DALKEY, Senior Mathematician, The RAND Corporation, 1700 Main Street, Santa Monica, Calif. 90406.*

Much long-range planning is based on poorly verified material, exemplified by the opinions of expert advisors. A technique for dealing with opinion involves the use of group judgement. In the past there has been little knowledge of the information processing characteristics of groups on which to design procedures for eliciting group judgements. Extensive experiments at RAND, utilizing controlled feedback methods have shown the

following. (a) Delphi procedures create a process that can be described quantitatively. (b) Iteration with controlled feedback usually results in improved group accuracy. (c) The mechanism of opinion change on iteration suggests the feasibility of more effective procedures

XIIG.4 A Synthesis Approach to Technological Forecasting, *ROBERT W. PREHODA, President, Technological Forecasting Associates, Inc 5051 Andasol Avenue, Encino, Calif. 91316.*

Technological forecasting (T/F) has been characterized by the refinement of several methodologies which show great promise in making long-range science and technology forecasts. These methodologies include trend curve analysis, Delphi, morphological networks, the scenario, cross impact matrix analysis and other approaches including the use of complex mathematical models. The synthesis T/F approach attempts to combine certain features of these methodologies for interim forecasts which are further refined by small 7 to 11 man T/F refinement teams following a working relationship developed through group dynamics. The paper will also explain the relationship of the "Hahn-Strassmann point" to long-range T/F.

XIIH.1 Chemical Alterations Resulting from Proton Irradiation of the Lunar Surface, *E. ZELLER, G. DRESCHHOFF and L. KEVAN, University of Kansas, Lawrence Kansas, 66044.*

Substantial chemical alteration of the lunar surface may be expected as a result of the flux of protons incident upon it. Water and hydroxyl ions are produced when silicates are irradiated with protons, and hydrocarbons may be formed if carbon-rich materials are present on the surface of the moon. Sputtering by solar wind protons can remove the reaction products at the surface but those formed deeper by the higher energy solar flare and cosmic protons can be retained. Chemical reduction can occur along the proton track by formation of trapped electrons and other reducing species. Protons can also act as reducing agents at the end of their tracks by forming either hydrogen atoms or hydride ions. These factors suggest that the chemical reactivity of the lunar surface will be considerably greater than that of terrestrial rocks.

XIIH.2 Effects of Simulated Solar Wind on Silicate Material Expected to be Present on the Lunar Surface, *J. P. DYBWAD, U. S. Air Force Cambridge Research Lab., Laurence G. Hanscom Field, Bedford, Mass. 01731.*

Simulated solar proton radiation causes surface roughening and lattice damage to silicate surfaces, and introduces hydrogen into the crystal lattice.

Reflection spectra of irradiated minerals show that chemical reactions between the hydrogen and metal oxides within the silicates are far less extensive than previously anticipated. Strong "radiation darkening" attributed to reduction of oxides to metals appears to have originated from contamination during early experiments.

Solar wind effects on lunar surface material should be minor during the average exposure time and should mainly affect the characteristics of absorption when this material is exposed to gases.

XIIH.3 Thermophysics of the Lunar Surface, *J. M. SAARI, Boeing Scientific Research Lab., P. O. Box 3981, Seattle, Wash. 98124.*

A review of the status of infrared measurements of the lunar surface will be presented. A new particulate thermophysical model of the lunar soil, which resolves past difficulties in interpreting eclipse and night-time cooling, will be described. The non-random distribution of thermal anomalies discovered during the 19 December 1964 eclipse will be discussed, and possible theoretical models presented. A quantitative critique of the anomalous cooling of Mare Humorum shows that internal heating is an unlikely explanation for it or for other thermal anomalies. Comparisons between anomalous infrared cooling and radar back-

scattering show certain correlations which may prove useful in the interpretation of thermal anomalies. Possible implications of lunar thermophysics to the Mercurian surface will be discussed.

XIIJ.1 Cost-Effectiveness Analysis for Evaluating Alternative Emergency Medical Care Recovery Systems, *E. HANITZSCH and W. K. HALL, Highway Safety Research Institute, The University of Michigan, Ann Arbor, Mich. 48108.*

The problem of transporting victims of emergencies from the scene of the event to a primary medical care unit has received renewed attention with the recent national emphasis on highway safety and with the developments of new recovery technologies. In this paper, a mathematical model is developed which considers a three criteria objective: minimize a specified function of the time between notification of the recovery system and arrival on the scene, maximize the victim treatment level until arrival at the primary care unit while minimizing this time interval, and finally, minimize a specified function of the time spent at the hospital transferring the patient and handling administrative details.

XIIJ.2 Effectiveness of V-STOL Networks in Metropolitan Areas, *J. F. DUVIVIER, Vertol Division, The Boeing Company, Philadelphia, Pa. 19142.*

Increasing airport congestions in the air and on the ground can be alleviated by alternate means of transportation. A generalized route network in a metropolitan area for the V-STOL aircraft is postulated and analyzed for the impact on the effectiveness and cost of the distribution of distances and turn around time which depends on the availability/ utilization relationships, block times, fixed and demand scheduling, and the allocation of aircraft to various levels of demand.

XIIJ.3 Energy Budget in Urban Road Transportation, *C. L. COHEN, F. A. P. FRISCH and J. M. KUCHARSKI, Challenger Research Inc., 1500 East Jefferson Street, Rockville, Md. 20852.*

At the present time almost all motor vehicles for urban road transportation are powered by internal combustion engines, causing pollution problems. In order to avoid such problems, new types of propulsion are being investigated. One of those is electric power. The present paper concentrates on the effect on local power sources, caused by widespread use of electrically propelled vehicles. A system for such investigations has been developed, applicable to the analysis of general energy budget problems.

XIIJ.4 Search and Choice in Transport Systems Planning, *M. L. MANHEIM, Massachusetts Institute of Technology, Cambridge, Mass. 02139.*

At its core, transportation is a technological problem in that the available alternatives are constrained by the present state of technology. But the real issues are not the alternative technologies but their ramifications—how each alternative transportation system affects differently the various segments of a society. This paper focuses on the processes of search and choice—how alternatives are generated and, more particularly, the interactions between search and choice. A "rational model," including its limitations, is first discussed. Then a more complete model, the PSP model, is explored and its applicability demonstrated. Finally, operational techniques to implement the PSP model are described.

XIIIA.2 Meteorological Satellites—Beyond the First Nine Years, *R. L. HALEY, Code SAN, Nimbus Program Manager, NASA Headquarters, Washington, D. C. 20546.*

The first meteorological satellite was launched April 1, 1960. Since that time many Tiros, Nimbus and applications technologically satellites have been launched and their results have advanced the state of knowledge in technology so that operational satellite systems now exist to provide cloud cover data in a routine manner. The paper will discuss past achievements, particularly the results of Nimbus B2 scheduled for launch in April 1969 and also developments that are now underway in future satellite programs to improve both short and long term weather forecasting.

XIIIA.3 Advanced Operational Meteorological Satellites, *CLIFF SPOHN, Director of Operations, National Environment Satellite Center, Washington, D. C. 20546.*

During the calendar year 1969 the first of a new generation of weather satellites will be launched. This satellite will significantly increase the capability of the weather satellite system by providing for night time sensing and for the addition of advanced sensors during the next several years. Details of the satellite system will be discussed.

XIIIB.1 A Mean-Variance Approach to Optimal Policy Choice Under Uncertainty, *CAROL CORRADO, Carnegie-Mellon University, Pittsburgh, Pa. 15232.*

Governmental actions aimed at achieving stability or at obtaining a target rate of growth pose a difficult decision problem. The solution of general problems of this nature with special emphasis on their uncertainty and dynamic aspects is the subject of this paper. In contrast to a certainty equivalence approach, the mean-variance method adds a second dimension of effectiveness to policy actions — a measure of uncertainty.

This paper extends much of Brainard's work in a dynamic fashion and addresses the problems of applying this method to practical situations. We find that it is adaptable to a broader range of policy problems than linear decision rules. The difficulty of estimating the terms reflecting uncertainty is also discussed and use of subjective probability distributions is suggested.

XIIIB.2 Decentralized Decision Making for National Development, *IRMA ADELMAN and FREDERICK L. GOLLADAY, Northwestern Univ., Evanston, Ill. 60201.*

This study develops a method for calculating the socially desirable subsidies for the promotion of socio-political and economic development. For this purpose a comprehensive dynamic linear programming model is solved for the maximization of complex objective functions composed of several indices of economic, social and political development. The dual solution is then analyzed in order to disentangle the shadow prices of investment resources, education and manpower. These shadow prices may be compared with market prices and appropriate taxes and subsidies for the inducement of social, political and economic objectives devised.

XIIIB.3 Macroeconomic Decision Model for National Planning, *JOHN Y. T. KUARK, Associate Professor of Statistics and Economics, University of Denver, Denver, Colo. 80210.*

The formalized approach to economic planning, supplements rather than supplants the discretionary policies of the decision-makers. A macroeconomic decision model is an analytical framework to achieve *co-ordination and system* in the many-sided problems on the basic goals of economic policy and the means that can be used for realizing these goals. The key note is to consider a set of simultaneous structural equations, depicting an economic system, which are comprised of endogenous variables such as target and auxiliary, and exogenous variables such as instrument and data. The behavior of the endogenous variables may be explained in terms of the exogenous variables via the "reduced form" of the structural equation system.

XIIIC.1 Lunar and Planetary Contamination Prevention and Detection, *MARTIN S. FAVERO, Public Health Service, U.S. Dept of Health, Education and Welfare, Phoenix, Arizona 85014.*

During the past 3 years 16 unmanned and 5 manned spacecraft have been assayed microbiologically. The results of these studies have shown that the levels and types of microbial contaminants detected on surfaces of space hardware or which accumulate on test surfaces exposed to the intramural air of spacecraft assembly areas are directly related to the degree of environmental and personnel control. Although the chief source of contamination is man, the intramural environment also can be a reservoir of contamination especially when control measures are inadequate.

XIIIC.2 Impact of Planetary Quarantine Requirements on the Viking '73 Project, J. MARTIN and LEO P. DASPIT, JR., NASA Langley Research Center.

There is a severe impact on a flight project that is to land on a planet of biological interest due to imposition of planetary quarantine policy. All major areas of a project are affected to some degree by this additional requirement. It requires that a new technology and discipline be established and integrated into project activities. The impact on the Viking Project to be discussed is in the general areas of management, flight equipment design, operations, and mission assurance. An overall view into these project activities and a few examples of how these areas are constrained by this requirement will be presented.

XIIID.1 Optimal Resource Allocations for Space Logistics Missions, J. F. DELFICO, Member of Technical Staff, Aerospace Corporation, Economic Analysis Office, Office of the Senior Vice President for Development, El Segundo, Calif. 90245.

Resupply of an orbiting space station is addressed to determine the capacity (cargo and men) and launch rate of a resupply vehicle which will minimize the total resource expenditure for the logistics mission. System cost and operational models are synthesized for manned and unmanned reusable systems, expendable systems and a mix of both reusable and expendable systems. The minimum cost parameters of the resupply system are determined by using an adaptation of the Lagrangian multiplier technique which deals with a non-linear objective function, and linear and non-linear inequalities as constraints. Trends and sensitivities are analyzed and the impact of the minimum cost parameters on overall system effectiveness is discussed.

XIIID.2 Methodology for Design of Long Duration Spacecraft, WILLIAM H. ALLEN, National Aeronautics and Space Administration, Office of Advanced Research and Technology, Mission Analysis Division, Moffett Field, Calif. 94035.

This paper deals with the problem of designing high reliability spacecraft systems for future, long duration, space missions which require system reliabilities much higher than those now acceptable for relatively short missions. Studies have shown that system reliability requirements can be met designing for maintainability and by including an inflight maintenance capability. Two approaches are described. The first uses a computerized program which selects either redundancy (parallel or standby) or sparing to raise the reliability of the basic single thread system on the basis of the least expenditure of critical resource (e.g., weight, volume). The second approach, using hand calculations with computer bookkeeping, follows a decision making logic, identifies "weak links" in terms of reliability, and forces evaluation of alternative methods either to strengthen the weak links, or to eliminate them by redesign.

XIIID.3 Systems Requirements Methodology for a Long Duration Apollo Logistics Spacecraft, H. S. ALEXANDER, Project Engineer, Research, Engineering and Test, Advanced Systems, Space Division, North American Rockwell Corp., Downey, Calif. 90241.

The extension of mission capability of an Apollo CSM used as a logistics vehicle (supporting a space station) from a 14-day active period to a 180 day quiescent period is examined. The methods used for determining subsystem change requirements are emphasized and key opened issues are identified. The approach proceeds from the "known" in terms of predicted environment and subsystem characteristics to the unknown through reliability extrapolation and identifiable failure mechanisms and degradation factors. A principle programmatic issue involves an acceptable test philosophy for a long duration system.

XIIIE.1 AAP Crew/Cargo Translation Concepts, GERALD J. WALKER, Office of Manned Space Flight, Headquarters, NASA, Washington, D.C. 20546.

This paper describes the conceptual planning for astronaut transfer in support of the Apollo Applications Program Orbital Workshop and Apollo Telescope Mount missions.

These concepts are to accommodate the intra-vehicular transfer and installation of crew quarters facilities and the extra vehicular operation of experiments.

XIII.E.2 Maneuvering Unit Development Programs, *HAROLD J. McMANN, Chief, Life Support and Stabilization Equipment, NASA, Manned Spacecraft Center, Houston, Texas 77050.*

This paper discusses the current and planned astronaut maneuvering unit development plans of NASA. Experiments M-509, "Astronaut Maneuvering Equipment," and T-020, "Foot Controlled Maneuvering Unit," which are planned for testing inside the orbital workshop of the Apollo Applications Program, are described. The advanced development programs for an Integrated Maneuvering and Life Support System and a manually controlled maneuvering unit are also covered.

XIII.E.3 Astronaut Worksite Performance Evaluation Program, *DAVID G. NORMAN, Manager, Astronaut Performance Program, General Electric, Valley Forge, Pa.*

This paper describes a program to:

1. Provide experimental flight data on astronaut's capability to perform work in an EVA environment through AAP Experiment M508.
2. Provide flight comparative data on the validity and fidelity of various ground-based, sub-gravity, simulation techniques.

Representative EVA tasks have been defined based upon research study and AAP Experiments D020, M151, M171, and M507. These tasks will be used to collect ground-based simulation and flight data. The data from this program will be used to broaden the knowledge base concerning zero-gravity worksite performance capability and provide valid information on what an astronaut can be expected to accomplish on future manned missions.

XIII.E.4 State of the Art of Space Tools—EVA/IVA, *CHARLES C. KUBOKAWA, Research Scientist, NASA-Ames Research Center, Moffitt Field, Calif. 94035.*

This paper describes the efforts to catalog that equipment specifically designed for extra vehicular and intravehicular activity work. Details of the equipment design, development status, and testing are presented. The more exotic tools are related to ordinary tools used on Earth.

XIII.F.1 Budget Allocations for New Faculty Positions, *JONATHAN HALPERN, Ford Foundation Project, Office of the Vice President, Planning and Analysis, 2171 Shattuck Avenue, Berkeley, Calif. 94704.*

A mathematical model is developed for the allocation of faculty positions to the nine campuses of the University of California. Taking predictions of student enrollment as the basis for future faculty needs, decisions—decentralized among the campuses—must be made about their allocations. The restrictions to be satisfied are: available budgets and policy decisions concerning student-faculty ratios. Subject to these constraints, the model computes lower bounds for the faculty expansion plans, i.e., the minimal new faculty positions needed, the stages of change in such ratios over time, the campuses to which positions are allocated, and the sensitivity of the planned allocations to changes in the budget.

XIII.F.2 Constant Work Model for Student Enrollment and Attendance, *KNEALE T. MARSHALL, Dept. of Operations Analysis, Naval Postgraduate School, Monterey, Calif. 93940; and ROBERT M. OLIVER, Office of the Vice President, Planning and Analysis, University of California, Berkeley, Calif. 94704.*

The need for reliable forecasts of student enrollments in the University of California has

necessitated formulation of models to describe student behavior. A simple independent trials model with constant work is considered where theoretical results are compared with independent data obtained from two cohort analyses of 1955 and 1960 Berkeley freshmen. These analyses indicate certain stationary properties of student behavior and the occurrence of temporary interruptions in their attendance patterns. The model shows in a simple way some fundamental underlying structure of student behavior patterns. Enrollment forecasts made with the model are briefly discussed.

XIII.F.3 The Use of Mathematical Programming Techniques in Designing School Finance Systems, JAMES E. BRUNO, Assistant Professor, UCLA.

The purpose of state aid to local school districts is twofold. First, to help support educational expenditures at the local level and secondly, to help insure equalities of educational opportunities for all students in the state regardless of the local "wealth" of the district. In order to determine the necessary state allocation of resources, the states have developed simplistic formulas. Since these formulas cannot simultaneously consider all resources and demands on these resources in a constrained environment, sub optimal utilization of resources usually results. By the use of mathematical programming models many of the shortcomings of presently used methods can be overcome. In this study a linear programming model which simulated the fiscal relationships in the California Junior College State Support Program was derived, then applied with excellent results. Several objective functions and design criteria (tax rate minimization, foundation level maximization) were used in the study.

XIII.G.1 Economic Order Quantities and Multiple Set-Up Costs, STEVEN A. LIPPMAN, Asst. Prof. of Quantitative Methods, Graduate School of Business, UCLA, Los Angeles, Calif.

A generalization of the standard lot size model is studied. The difference here is that the cost of ordering includes a jump of size H every M units in addition to the linear and set-up cost. We refer to this cost function as the multiple set-up cost function, and it arises in connection with transportation via fixed size vehicle, capacitated production runs, and machine tool wear-out. We obtain planning horizon theorems and characterize the form of an optimal policy for both the finite and infinite horizon problems. Simultaneously, some not widely known results about the lot size model are rigorously derived.

XIII.G.2 Making Short-Run Changes in Production when the Employment Level is Fixed, MATTHEW J. SOBEL, Yale University, New Haven, Conn.

In a factory with a given employment level, often there are opportunities to make adjustments to that level via overtime, subcontractors, etc. We characterize optimal production policies for a single product having stochastic demand when the temporary adjustments have costs proportional to their magnitudes. Several cases are treated including infinite horizon problems, which have optimal policies that depend on two parameters that can be computed with relatively small linear programming problems. The computations exploit the structure of the streamlined separable version of an appropriate Markovian decision problem.

XIII.G.3 Some New Models for Inventory and Production Planning Operations, I. KARAYALCIN, Garanti Blokleri B-5 Etiler-Istanbul, Turkey.

In the first section of this paper, the existing planning and inventory models are studied in general.

In the second section planning function and the existing models for inventory and "economic manufacturing quantities" have been studied.

In the third section, allocation and planning of inventories problem are taken together and a Combined Mathematical Model for inventory problems connected with allocation

Operations is built. The possibilities for the solution of this model are discussed and a general solution is proposed. Finally an approximate mathematical solution is developed.

XIII.G.4 A Quantitative Approach to Span of Control Problem, *I. I. KARAYALCIN, Garanti Bloklari B-5 Etiler-Istanbul, Turkey.*

The most interesting papers written for Span of Control are classified and discussed. Graicuna's Formula (1923) is rederived based on some assumptions, and a few modifications are proposed to develop and extend this formula. A survey is done to determine the level of span of Control in Turkey and its results are compared with two other surveys done in USA previously. All three of these surveys are statistically analyzed and interpreted. A total value type model and a queuing model are built to determine the optimum Span of Control.

XIII.G.5 Evaluation of Organization Criteria, *I. I. KARAYALCIN, Garanti Bloklari B-5, Etiler-Istanbul, Turkey.*

In this paper forty different criteria for a sound Organizational Structure are summarized and discussed. An experiment is designed to give priorities to those forty criteria with one hundred managers from different levels in different companies in Turkey using a special comparison technique. The results are then discussed.

XIII.H.1 Physical Lunar Parameters Via Radio Tracking of Space Probes, *P. M. MULLER and W. L. SJOGREN, Jet Propulsion Laboratory, Pasadena, Calif. 91103.*

During the past four years the Ranger, Surveyor, Lunar Orbiter, Pioneer and Mariner missions have supplied an abundance of radio tracking data, which have been used for determinations of various physical constants of the moon. A review of these constants will include estimates of GM, the position of the moon with respect to the Earth, the radius of the moon, and the gravitational field variations. Recent reduction of the Lunar Orbiter data has determined a surface mass distribution over the Earthside hemisphere showing the largest anomalies in the ringed seas. Data of a similar quality over the lunar farside must be obtained before a complete dynamic model can be developed to give the necessary precision to the trajectories of future lunar missions.

XIII.H.2 Apollo Lunar Geology Experiment, *M. H. HAIT, JR., U. S. Geological Survey, 601 East Cedar, Flagstaff, Arizona 86001.*

The Apollo Lunar Geology Experiment will supply most of the geologic information on the Apollo lunar landing missions. The experiment is oriented toward an understanding of materials, features, and processes in the vicinity of the Apollo landing sites. These missions offer the first opportunity to correlate carefully collected samples and photographs with a variety of descriptive data on the upper portions of the mare basin filling. The Apollo Lunar Geologic Experiment is lunar field geology, carried out in a new geologic environment under extremely difficult mobility constraints and within short time limits. Carrying out the Lunar Geology Experiment under these difficult conditions necessitates a new exploration philosophy in which the astronaut used special sampling tools and is assisted in real-time by a team of geologists on Earth using advanced computer techniques for compiling and analyzing geologic data.

XIII.I.1 A New Dimension to In-Fight Maintenance Capability Via Hardware Design (Two Year Life Support Systems), *DALE E. SPOND, Group Engineer, Martin Marietta Corp. Denver, Colo. and DONALD G. FULLERTON, Senior Engineer, Martin Marietta Corp. Denver, Colo.*

Three levels of design for IFM capability are: 1) Packaging for accessibility to aid in removal and replacement of equipment; 2) Provisioning of equipment and tools for repair; and 3) Designing IFM capability into the hardware.

Current IFM philosophies favor Level 1 for long duration missions. Level 1 allows the use of existing hardware and requires a minimum of crew training. No capability to repair, however, requires sparing bulky equipment, which results in volume and weight penalties.

Level 2 is not attractive since most existing hardware requires skilled technicians and complex equipment for repair.

Level 3 offers a new dimension to IFM capability. When hardware is designed for maintainability in space, the repair tasks become simple and less equipment is required. Piece part rather than component commonality becomes possible. For example: Level 1 spares a valve, while Level 3 spares the valve seals.

This paper presents hardware and support equipment design concepts for a Level 1 and Level 3 IFM capability.

XIIIJ.2 Symbol-Oriented Approach to Automated Failure Analysis, *W. W. HAPP, NASA/Electronics Research Center, Cambridge, Mass. 02139.*

Computer-oriented procedures are developed to assess the error in performance of electronic circuits and similar systems if one element in a multi-component system fails.

Computer-generated expression for the anticipated error are essential for several distinct applications:

- (a) To identify the component in which error is occurring.
- (b) To derive approximate mathematical models it is necessary to assess if elimination of an element perturbs the system response beyond a preassumed limit.
- (c) To examine the concurrent effect of two or more errors.

The first part of this presentation will introduce the basic concepts and terminology. Next the symbol error functions will be defined and basic properties will be defined. The third section will outline a systematic development of a calculus of symbolic error functions. The concluding section attempts to relate this investigation to other current developments on computer-oriented symbol manipulation techniques.

XIIIJ.3 On Evaluating the Operational Performance of Digital Circuits, *ARTHUR W. LO, Department of Electrical Engineering, Princeton University, Princeton, N.J. 08540.*

The reliability of digital information processing systems relies heavily on the operational performance of the elementary digital circuits, which are interconnected in complex patterns to perform complex system functions. Some departure from the conventional circuit analysis approaches is necessary to evaluate the highly nonlinear circuits especially for digital operation. This paper discusses the basic requirements of digital operation and the aspects of circuit behavior essential to reliable and efficient digital operation, with particular emphasis on the static and transient noise margin and the logic propagation delay, and means of evaluating and testing of practical digital circuits.

XIIIJ.4 Integrated Circuits, Reliability and Testing, *JEFFREY J. BOWE, NASA/ Electronics Research Center, Cambridge, Mass. 02139.*

For space systems of the 70's, in which reliability is a major factor in the choice of integrated circuits, it is often difficult to determine whether MOS or bipolar transistor integrated circuits are preferable. In determining present reliability capability and in projecting future capability, the specifics of the application are significant. Both the users and the manufacturers viewpoints are required in integrated circuit development to achieve optimal reliability.

The advantages and disadvantages of the MOS integrated circuit, and of the bipolar integrated circuit are weighed and evaluated in the light of the above criteria.

Consideration is given complementary integrated circuits, in which the advantage of greatly reduced power consumption is tempered by the requirement of more difficult fabrication processes.

The need for improved testing for characterization of integrated circuits, and especially of LSI, is emphasized.

Examples from experience with NASA systems are cited. This is a new paper which has not been published elsewhere.

XIVA.3 Space Science for Global Data Management, *KERNS H. POWERS, RCA, David Sarnoff Research Center, Princeton, New Jersey.*

The need and the opportunity for gathering, processing and distributing data on a global basis will provide space science planners with one of the next decade's great opportunities and challenges.

XIVB.1' Group Practice and Efficient Health Services Delivery, *EDWARD L. DOLINSKY, Assistant Chief, Office of Group Practice Development, Community Health Services, U. S. PHS, Washington, D.C. 22203.*

The increasing expense associated with the single practitioner office has led to cost-sharing arrangements to provide efficiency. This paper examines the group practice concept which allows physicians to concentrate on achieving the most efficient and compatible set of working arrangements within which to practice. It also helps obviate problems resulting from the vast explosion of technical, medical information by reducing the need for physicians to have a working knowledge of so many areas of the art. Types of groups and organization are discussed with some related information about obtainable productivity and efficiency. Specific advantages for patients are considered.

XIVB. 3 Imperatives for Health Systems Research, *MERWYN R. GREENLECK, Director of Research, Kaiser Foundation Hospital, Portland, Oregon 97217.*

With the acceptance of the valued position that medical care is an American right, it is necessary to accept two corollaries:

1. Those medical care services must be delivered to the population that are expressly appropriate to need, and
2. Only the most economical appropriate form of medical care must be utilized.

Generally, medical care researchers and medical care practitioners have engaged in interesting and exciting work, however, without relating to each other in any meaningful way. This paper defines a set of imperatives for future medical care research and sets forth a series of steps to study the operations of the health care system.

XIVB.4 CORE City Health Care—A Resource Management Challenge, DAVID L. COWEN, Manager, Denver Department of Health & Hospital, West Sixth and Cherokee Streets, Denver, Colo. 80204.

This paper introduces the operations researcher to some of the opportunities that exist for applying systematic analysis methods to improve urban health care delivery systems. A brief discussion of Denver's system for delivery of comprehensive health care to the disadvantaged is used to point up areas of critical concern. Problems encountered in the implementation and operation of Denver decentralized health care system are depicted as representative of a larger class of health resource management problems which must be addressed on a national basis. Emphasis is focused on planning and operational decision-making functions which have significant potential for improvement through application of operations research and systems analysis.

XIVC.1 Space Medicine, CHARLES A. BERRY, Director, Medical Research and Operations, MSC, NASA, Houston Texas, 77058.

To date, there has been limited data gathered on the exposure of man to the space environment. If man is to be exposed to longer duration space flights, much additional information is required on the effects of space flight conditions on his medical and physiological processes. A summary of significant results of Apollo flights and implications for the future will be presented by the Medical Director of the Manned Space Flight Program.

XIVC.2 New Technologies for Human Decision Making, WARD EDWARDS, Head, Engineering Psychology Laboratory, University of Michigan, 330 Packard Road, Ann Arbor, Mich. 38107.

Traditional decision-making procedures either display the information to a decision maker who must make up his mind or fully automate the process. Experiments and simulation show that decision-making systems in which men make subjective, judgmental inputs to formally optimal decision-making algorithms outperform both types of traditional systems. In future decision-making systems, men will make value judgements, judge certain kinds of uncertainties, and invent acts and states; algorithms will decide.

XIVC.3 Architectural Psychology, CALVIN W. TAYLOR, Professor of Psychology, Building 404, University of Utah, Salt Lake City, Utah 84112.

Environments have been designed for mechanical efficiency rather than for human use. The unseen cost in much architecture is the cost to the occupants as measured by fatigue, boredom, monotony, inefficiency, and resentment. Habitability factors for spacecraft or factories or homes are difficult to define, measure, or incorporate. Although architectural psychology is a new discipline, it is clear that a measure of the performance of a building can be made using man as the measure and the use of this measurement will be a contribution to human well-being as well as system efficiency.

XIVC.4 Performance Prediction Techniques, EDWARD C. WORTZ, Project Scientist, Department of Life Sciences, AiResearch Division, Garrett Corp. 9851 Sepulveda Blvd., Los Angeles, Calif. 90009.

Current physiological, psychological, and modeling techniques have been used to assess and predict human performance. As a result of these applications, the techniques are being modified. The direction and degree of these changes will enable their application beyond the systems which have aided their development.

XIVC.5 Perception of Laser Light (Research Related to Laser Holography and Laser Display Systems), CARL F. ASIALA JR., E422 Bldg 32, Post 380, McDonnell Aircraft Company, St. Louis, Missouri 63166.

The uniqueness of the LASER centers about the differences between observations using coherent and noncoherent light. The only area of major difference is that of the granularity associated with a coherent light observation.

Only a limited subjective impression can be stated for the effect of granularity on the observer. Many observers have indicated that their ability to concentrate on an image which possesses sparkle is considerably impaired.

This research is the first known attempt to move from the subjective impression to a numerical expression of a difference, if it exists, between coherent and noncoherent sources.

This research assesses the effects of the LASER granularity phenomenon on brightness discrimination. Utilizing the psychophysical method of limits, varying shades of gray stimuli were presented to subjects under white, noncoherent red, and Helium-Neon LASER light conditions.

XIV.D.1 Contractor Basic Accounting Records as a Data Source for Cost Analysis, JOSEPH STRING, *The Rand Corporation, Santa Monica, Calif. 90406.*

This paper reviews the current contractor cost reporting procedures and identifies the deficiencies which degrade the usefulness of such data in attempting to develop cost analysis techniques. A new procedure, currently under development, is discussed. This new procedure utilizes more detailed cost breakdowns, such as the basic contractor accounting records. Such data would be provided on magnetic tape to facilitate both reporting, storage, and access.

XIV.D.2 Cost—A Basic Design Parameter, L. MERRITT McKAY, *Advanced Systems and Technology, McDonnell Douglas Astronautics, St. Louis, Missouri 63166.*

Cost analyses are a fundamental part of any advanced system study and generally provide the most important single figure of merit for comparing alternatives. The value of the cost analysis can be enhanced by (1) deriving improved methods for extracting costs (thereby increasing the confidence in the estimate) and (2) introducing cost as a basic design parameter in the initial design tradeoff.

The cost data from several historical aerospace programs was broken down to the subsystem level or below and identified by labor category, function, design requirements and performance characteristics. This data was normalized and estimating relationships determined.

To accomplish the second goal, the cost estimating relationships, organized into a cost model, were coupled to a spacecraft sizing model which is based on parametric relationships and designed to recognize a wide variety of subsystem and operational mode alternatives.

XIV.D.3 Econometric Analysis of Earth Orbital Transportation Systems, CAREY H. RUTLAND, *NASA Marshall Space Flight Center, Huntsville, Ala. 35812.*

This paper reports on the analysis of transportation systems cost and identifies the sources of high cost in present systems. Tradeoff studies indicating areas offering the most cost reduction potential are shown. The paper reports on current study activities aimed at identifying in more explicit terms the areas where cost reductions can be effected and how cost considerations affect the design approach. Typical examples are shown for some subsystems of the overall transportation system.

XIV.D.4 Manned Space Flight Information Network Extension System and its Application for General Systems Cost Modeling, RICHARD C. TUEY, *NASA, OMSF, 600 Independence Avenue, Washington, D.C. 29546.*

This paper discusses establishment of a system of rapid information retrieval and on-line display suitable for use by program management personnel. The system is described and its application to the case of manned space flight program cost modeling presented.

XIVE. 1 Problems of Abort from Manned Spacecraft, ARTHUR L. GREENSITE, *General Dynamics, Convair, San Diego, Calif.*

Problems of abort from a disabled space vehicle will become more acute as manned space missions increase in sophistication and complexity. Abort procedures developed in the Mercury, Gemini, and Apollo missions are briefly reviewed and critical problem areas are identified. Particular emphasis is placed on orbital and super orbital missions which may require abort capabilities of substantially greater sophistication than those which are currently operational. Various conceptual and design philosophies which have evolved from these considerations are described and evaluated. Areas requiring further research and development are identified.

XIVE.2 EVA/IVA Flexible Light Weight Umbilicals, DONALD A. MYERS and HAROLD J. RICHTER, *Propulsion and Mechanical Engineering Dept., Martin Marietta Corp., P.O. Box 179, Denver, Colo. 80201.*

Development of lightweight flexible fluid umbilicals and umbilical systems for use in zero "G" environments has attracted little attention to date. This paper will define the progress achieved in the construction and testing of umbilicals intended for use as the astronaut maneuvering units support line. The objective is to produce a fluid flow system which offers less maneuverability constraint during space operation. Also unveiled: a fluid support umbilical designed to position an astronaut in a fixed attitude at a station during the nonoperating cycles of his propulsion unit. Principles of a more flexible umbilical design include nonintegrated materials of construction and the addition of an internal umbilical cable. Functionally the cable absorbs the longitudinal loading due to internal pressure thus permitting broader material selection and methods of construction essential to improve flexibility. These concepts represent substantial improvements over present state-of-the-art hardware.

XIVE.3 Spacecraft Habitability for Future Manned Missions, RICHARD B. WEBER and JAMES D. GATTS, *Martin Marietta Corp., Denver, Colo.*

Spacecraft habitability denotes the total subject concerned with the astronauts' occupancy of the spacecraft. This subject includes waste management, food management, personal hygiene, artificial gravity living quarters, duty stations, garments, crew recreation and refuse management.

To date missions have been successfully flown with fairly primitive living conditions and the spartan mode of existence has prevailed. However, as the missions become longer in duration, health, motivation and morale loom as problems of ever increasing magnitude, and requirements for spacecraft habitability provisions take on new dimensions. In this paper the total subject is surveyed, major problem areas are identified and a philosophy for resolution is proposed. The philosophy includes some of the "make it like home" attitude and also considers the change of address.

XIVE.4 EVA Stabilization Shoes, A. L. GREENSITE and E. H. WRENCH, *General Dynamics, Convair, San Diego, Calif.*

Various space walks conducted during the Gemini program and by the USSR have indicated that the astronaut experiences considerable fatigue due in large part to the conscious and continuous effort exerted to maintain attitude. A mass expulsion jet shoe developed by NASA permits attitude control during translation in a mode analogous to swimming, but requires translation and a head-first orientation during travel.

This paper proposes the use of a two degree of freedom control moment gyro for attitude control of an astronaut during EVA. The units are shoe mounted, and controlled by muscle action about the ankles. A unique arrangement permits precessional feedback forces to be applied to the foot for tactile rate sensing.

Preliminary studies indicate that two shoes weighing five pounds each together with a two hour battery supply weighing four pounds would permit tumble sensing and three axis maneuvers at reasonable rates.

XIVE.5 Gravity Independent Liquid Collection and Fluid Phase Separation System, W. E. JAMES and D. J. HOLECEK, Martin Marietta Corporation, P. O. Box 179, Denver, Colo. 80201.

This system is applicable in any instance where liquid is desired to be collected from a gaseous environment and separated into pure liquid and pure gaseous phases. The necessity of this system derives from space missions where the collection of wash and waste water is desirable.

The separation system is composed of blower, venturi, separator, retention tank, and miscellaneous valves and fittings. The only moving part in the entire system is the vacuum blower which is used to: 1) provide a suction at the liquid collection head and 2) induce a differential pressure across the hydrophilic screen in the separator.

The separator operation principle is unique in that centrifugal force and a single hydrophilic screen is used for liquid/gas separation. The separation system is also unique in its operation principle.

XIVF.1 Stability of University Input Coefficients, DAVID BRENNEMAN and DAVID HOPKINS, Ford Foundation Project, Univ. of Calif., Office of the Vice President, Planning and Analysis, 2171 Shattuck Avenue, Berkeley, Calif. 94706.

A variety of input-output and activity analysis models have been suggested and occasionally implemented as tools to aid university administrators in such diverse problem areas as predicting demand for faculty, simulating costs of policy decisions, and finding minimum cost methods for college or departmental reorganization. These models make extensive use of coefficients calculated for a single period and assumed to be constant over time. To test this assumption, coefficients were calculated for certain departments at the University of California Berkeley campus. Results of this study are reported with some observations on the possible causes of the instability found in several sets of coefficients.

XIVF.3 Non-Tenure Faculty Appointment and Retention, ROBERT STANFORD and ROBERT OLIVER, Ford Foundation Project, Univ. of Calif., Office of the Vice President, Planning and Analysis, 2171 Shattuck Avenue, Berkeley, Calif. 94704.

A mathematical model of a non-tenure faculty appointment and retention system has been developed in order to study the effects of various policies on faculty composition and behavior. Under simplifying assumptions, it is possible to relate resignation and promotion rates and thus calculate the costs of new appointment and retention policies. For this paper, the authors will compare theoretical results obtained from their model with data gathered on several campuses of the University of California.

XIVG.1 Modeling Air Antisubmarine Tactics With Data, FRECKERICK G. STAHL, Senior Analyst, The John D. Kettelle Corporation, 1501 Wilson Blvd., Arlington, Va. 22209.

Computer simulations of an aircraft attacking a submarine typically put much aircraft tactical control in the computer program, thereby reducing ease of using the model in experiments prior to field tests. A recent model was developed which involves extensive control of tactics by data. The model is a variable, time-step, Monte Carlo simulation, wherein tactics data consist of: (a) control of generation of fixes from sensor contacts, (b) patterns consisting of points, aircraft operations, and locating and sizing rules; and (c) rules for selecting operating patterns. Experience shows this scheme to be complex but comprehensive and efficient.

XIVG.2 Field Tests of Operations Research Models, *A. S. BOLTHOUSE and A. M. JOHNSON, IBM Corporation, Federal Systems Division, Electronics Systems Center, Owego, N.Y. 13827.*

A variety of reasons for constructing models of military weapon systems are discussed, some of which are unique. The ways in which regular training missions and routine military exercises can be used to field test certain types of weapon system models are suggested. The authors indicate the advantages and difficulties of field testing certain types of models, based on their own experience.

Examples are given of two relatively simple models designed to diagnose and correct what appeared to be malfunctions of an avionics subsystem which was operational in the field. The model, detailed in this paper, was graphical and the solution to the operational problem required an error compensation computation using a nomograph developed for that purpose.

XIVH.1 The Lunar Receiving Laboratory, *TED H. FOSS, NASA Manned Spacecraft Center, Houston, Texas 77058.*

Astronauts and rock samples from Apollo lunar surface missions will be placed in quarantine in the Lunar Receiving Laboratory for a period of at least 21 days. During this period, the returned lunar samples will be tested to determine whether they contain any pathogens that might be hazardous to terrestrial life forms.

Because of the quarantine, time-critical chemical and mineralogical studies will be carried out on some samples behind the biological barrier. These will include low-level radiation counting, gas analysis for rare gases and organic constituents, various geophysical measurements, and a preliminary chemical and mineralogical analysis to insure meaningful sample distribution to Principal Investigators.

XIVH.2 Post-Apollo Lunar Geologic Exploration, *ALFRED H. CHIDESTER, U. S. Geological Survey, 601 East Cedar, Flagstaff, Arizona 86001.*

Lunar geologic investigations following the first two or three Apollo landings will utilize increasingly sophisticated systems for carrying out operations on the lunar surface, and for providing essential Earth-based support. Surface investigations will be carried out by man at carefully selected sites covering only a very small part of the lunar surface, and by remotely controlled surface vehicles carrying automated analytical systems operating over extended traverses between manned sites. The choice of sites and the geologic objectives of individual geologic missions will be influenced by engineering considerations, but will depend largely on geologic considerations.

XVA.1 Potential Contributions of Orbital Earth Resources Data to Urban Planning, *CHARLES T. N. PALUDAN, Chief, Measuring Instrumentation Branch, George C. Marshall Space Flight Center, Huntsville, Ala. 35812.*

A major problem facing urban planners is that of maintaining up-to-date land-use data. Ground surveying of land-use is very time consuming, with the result that information is frequently inadequate and often of less value than would be desirable.

It can be demonstrated that gross land-use patterns can be recognized on multispectral photographs at a scale of 1:100,000 or larger. It is assumed that coverage of all major U. S. cities by multispectral photography is cost effective only by utilization of orbital cameras yielding scales as small as 1:1,000,000. Some potential contributions of such data are discussed. Commercial production of data inputs and commercial uses of the data are envisioned.

XVA.2 From Space Technology to Profits, *M. F. RUDY, Senior Executive Technology Utilization, 1700 East Imperial Highway, North American Rockwell, El Segundo, Calif. 90245.*

Profitably converting our extremely valuable space technology into new and useful products and processes is a fascinating challenge filled with opportunities for the qualified and motivated individual, as well as for large and small corporations. The author will present a number of interesting and different methods of managing the technology retrieval, enhancement, proof of concept, and transfer activities that North American Rockwell has developed and tested in support of commercial utilization of new aerospace technology.

XVA.3 Space Photography—Window to Discovery, *WILLIAM V. TROLLINGER, Trolling-Gosney and Associates, Inc., 70 West 6th Avenue, Denver, Colo. 80204.*

Space photographs taken from the Gemini and Apollo missions have proven to many Earth scientists that these photos are far more than "interesting pictures taken from a previously unobtainable perspective—" they represent a new tool for unlocking the Earth's store of mineral resources. By careful scrutiny of the space photographs already available, experienced geologists have analyzed and mapped many regional structural features such as major faults, upwarps, etc. These data provide a clearer understanding of the fundamental structural character of the crust, and furnish clues to the tectonic evolutions of the Earth.

XVA.4 Manufacturing in Space: Low and Zero Gravity Manufacturing in Orbit, *HANS F. WUENSCHER, George C. Marshall Space Flight Center, Huntsville, Ala. 35812.*

Manufacturing processes are reviewed and three categories are established:

1. Processes which work also in orbit.
2. Processes which work much better in orbit.
3. Processes which work only in orbit.

The uniqueness of the last category rests on utilization of the low and zero gravity environment and two unique process groups are discussed:

- A. Bouyancy and thermal convection sensitive processes.
- B. Molecular forces controlled processes.

Some basic physical data is shown and seven basic processes are described. Examples of unique products are given for each of the process groups.

XVA.5 An Earth Resources Satellite, *BERNARD P. MILLER, Manager, Earth Resources Satellite Program, RCA, Astro-Electronics Div., P.O. Box 800, Princeton, N.J. 08540.*

Advancements in the fields of space technology and remote sensing have made possible the development of a satellite for the assessment of the Earth's resources from space. This satellite can provide multi-spectral pictures. The photo image maps can be used for the management of land and water resources.

A system design concept using the NASA TIROS M spacecraft is proposed. The spacecraft will fly in a near-polar sun-synchronous orbit. Advanced equipment using laser scanning of film is described for reconstituting the pictures transmitted from the satellite to Earth.

It is concluded that the satellite and its sensors are within today's state-of-the-art, and that the data provided can be of immediate benefit in resource planning and management.

XVB.1 Management of Power and Energy Resources, *EARL EWALD, Chairman of the Board, Northern States Power Company, Minneapolis, Minn.*

Energy is as basic to human life as are air and water. Man began with only the energy of his muscle, fueled by food. He harnessed animal power, fire, steam, electricity, and petroleum. To support the Earth's growing population at higher standards of comfort and convenience, man will need more and more energy. Sources of supply of fossil fuels are exhaustible but they are augmented by nuclear sources and the hope for fusion.

Conservation of these supplies, plus the acute requirement to control atmospheric pollution from fuel use, dictate careful management. An increasing share of man's growing energy needs will be converted to electricity.

XVB.2 Management of Well Information for the Petroleum Industry, JAMES M. FORGOTSON, JR., Vice President, Petroleum Information Corp., 1640 Grant Street, P. O. Box 2612, Denver, Colo. 80201.

Approximately 2,100,000 wells have been drilled in the search for oil and gas within the U.S. Nearly a million of these have records of sufficient quality to include in a computer based data system. Major types of data for each well include location, ownership, geology, engineering data concerning drilling and production, and results of tests to determine presence and amount of oil or gas within the Earth formations penetrated. Data collected from operator of wells, state records and service companies that perform tests or analysis are set into a formatted computer file system containing several hundred million information elements. Users, most of the major oil companies, apply mathematical and graphics techniques to these data to aid management of a three billion dollar per year oil and gas exploration, production and transportation industry.

XVB.3 Management of Waste Heat Discharges of Power Facilities, N. S. LYNN and L. W. ROSS, Department of Chemical Engineering, University of Denver, Denver, Colo. 80210.

Waste heat is a serious contaminant of rivers and streams, and the problem has become critical with the advent of large-scale nuclear power installations. The present paper describes laboratory experiments and mathematical models that we have developed at the University of Denver, for prediction of temperature in thermally polluted waterways.

This investigation is unique in that it considers convective motion within the waterway, rather than assuming constant velocity. Free convection contributes greatly to natural cooling and gives rise to unusual "hot layer" flow effects. These effects can be predicted by solving the appropriate equations of energy and motion.

XVC.1 The Impact of Apollo Application on Space Station Engineering, W. D. GREEN, Manager, Apollo Applications Mission Definition, NASA, Washington, D.C. 20546.

AAP is a major step in the transition of manned space flight from the pioneering missions of the first decade towards a future period in which space will be occupied for purposes of exploitation. This paper stresses those facets of the AAP which are most directly significant to future space station engineering including operational determination of system requirements, biomedical, scientific and technology data collection and management of an orbital operation over a period of several months.

XVC.2 Manned Exploration of Mars and Venus Using Chemical Propulsion, RICHARD R. TITUS, Senior Research Engineer, United Aircraft Research Lab., East Hartford, Conn. 06108.

The many analyses performed for manned missions to the neighboring planets have generally concluded that advanced propulsion systems, such as nuclear, will be required to meet the large mass requirements. This paper outlines a means of performing manned flyby and stopover missions to Mars and Venus as part of a well integrated space program which utilizes chemical propulsion only and Saturn V launch vehicles. By the use of unique mission modes, this space program provides heliocentric abort capability, low-energy missions of short duration, and such commonality between all Mars and Venus missions that a single spacecraft with "off the shelf" upper stages can be conceived.

XVC.3 Alternate and Backup Planning as a Function of the Probability of Successfully Achieving Preplanned Mission Objectives, E. H. BAUER and E. F. FLEISCHMAN, Marshall Space Flight Center, NASA, Huntsville, Ala. 35812.

The operational sequence of the Apollo Applications Program can be analyzed as an aid in backup and alternate mission planning. The basic AAP mission consists of five vehicles, or

hardware units, launched sequentially to achieve various mission objectives. Each hardware unit has associated with it an inherent probability of failure. Efficient use of limited backup units in the event of a failure anywhere in the mission must be established.

In analyzing this problem, success probabilities for achieving various mission objectives are computed for each possible sequence. Combined with weighted values assigned to each objective, backup and alternate plans can be made to maximize the probability of achieving the mission objectives.

This paper presents a narrative of the analysis, flow, and description of the computer program developed.

XVC.4 Technology Flow for Future Space Activities, C. A. BRAUNWARTH, Senior Engineer, Mission Analysis Section, Martin Marietta Corp., Denver, Colo. 80201.

The continuing U. S. Space Program will require advances in the state of the art in several areas of technology. The technology flow available for future manned Earth orbit operations, manned lunar exploration, and manned planetary exploration is studied, and the apparent adequacy of the technology flow is discussed. The assumed U. S. Space Program is found to satisfy most anticipated future technology requirements. The entire space program is viewed as a system whose outputs are the major space goals dictated by national policy. In this way, short term objectives are tempered by long term technology requirements, and the space program is designed to advance at the most advantageous rate on all fronts.

XVD.1 Computers and Their Role in the Successful Development and Implementation of Operations Research Models, RALPH ORAVEC, Price-Waterhouse and Co., 60 Broad Street, New York, N. Y. 10004.

The increasing of availability to operations researchers of high-speed computers in general, and time-sharing computer totals in particular, offers a singular opportunity for improving the frequently discussed "implementation gap" surrounding commercial applications of OR. A number of applications of operations research to problems arising in a business environment will be described. The role of the computer in improving communications between the OR practitioner and business management in both the model structuring and model implementation phases of a program will be discussed. Particular emphasis will be given to the essentially iterative nature of the analyst's approach to real world problems and methods which have proved successful in maintaining communications between OR analyst and other team members.

XVD.2 Seven Days in May—An Accurate Forecast of Weekly Cash Position a Year in Advance, ALAN M. CUNNINGHAM, Touche, Ross, Baily and Smart, 1801 1st National Bank Bldg., Denver, Colo. 80202.

This paper presents a specific application of a general conceptual solution to the problem of forecasting weekly cash position as much as a year or more in advance. Using the example companies profit plan and capital expenditures budget as a forecast foundation, this technique uses a modeling approach to describe the dynamics of week-to-week working capital changes.

Applying the same conceptual approach as is used in year-to-year cash flow analysis which adds depreciation charges back to profits, this full accrual — addback method insures that the specific cash level for a particular day will be in error only by the amount of deviation from the profit and capital expenditure plan, plus or minus a noncumulative random error factor.

XVE.1 Educating for the RFP, *P. LEVINE, Adjunct Associate Professor, Brown University, and Project Manager, AVCO Space Systems Division, Lowell, Mass. 01851.*

As all of us in the Aerospace industry know, when the chips are down, the big winner is likely to be the corporation with the best overall response to the Request for Proposal. As technology proliferates the skills of organization, design, planning, etc., as well as those of specialized technology, assume ever increasing importance in advanced system procurements. But, what is the educational system doing to prepare engineering graduates to match wits with the RFP?

As a result of the experience in teaching an Aerospace Vehicle Design course for several years and in responding to many RFP's during his career, the author has devised and implemented a course study plan whereby the student is in fact, confronted with the problem of "responding" to an RFP. The course methodology, problem areas and experiences are discussed.

XVF.1 Redirection Policies at Campuses of the University of California, *KNEALE T. MARSHALL, Dept of Operations Research, Naval Post Graduate School, Monterey, Cal. 93940.*

A basic policy at the nine University of California campuses has been to accept all qualified undergraduate students. Some campuses have now reached capacity, and redirection of some new students to second choice campuses is necessary. The problem of determining optimum redirection policies to obtain specific goals is the concern of this paper. Models of student intra- and inter-campus flow are formulated. Goals considered include maximizing of total student enrollment subject to capacity constraints, and attainment and maintenance of a 40/60 ratio of lower division to upper division students. Conflicts resulting from multiple goals are illustrated.

XVF.2 Macro-Analysis of the American Educational System, *ALEXANDER M. MCOD, Director of Public Policy Research Organization, and Professor of Administration, University of California, Irvine, Calif. 92664.*

Educational research has been mainly concerned with learning theory and educational technology; almost no attention has been given to it as a production process responsible for producing educated individuals. The U. S. Office of Education has recently developed some macromodels of the public school system. The Coleman nationwide survey of 1966 provided much of the data needed for estimating parameters of such models. Now for the first time we have quantitative measures of some of the important factors in the educational process. The development of some of these measures and some of their policy implications are explored.

XVF.3 Expansion of University Facilities to Accommodate Increasing Enrollments, *ROBERT SANDERSON, Ford Foundation Project. Univ. of Calif, Office of the Vice President, Planning and Analysis. 2171 Shattuck Avenue, Berkeley, Calif. 94704.*

A mathematical model is developed for the economic expansion of facilities at different campuses of the University of California for a given sequence of enrollment forecasts. Based on total projected enrollments for the University System, the model computes a minimum total cost expansion program, i.e., the stages at which to expand existing campuses or to build new ones and the enrollments that should be allocated to those campuses. The model is formulated as a network flow problem in which non-zero flows on certain arcs incur fixed charges; a minimum cost flow is found by a branch-and-bound technique.

XVF.4 Post-Secondary Education for Disadvantaged—an Analysis of Alternatives, MIKLOS WASS de CZEGE, Research and Development Section, Bureau of Budget and Management, State of Wisconsin.

This paper examines alternatives to increase post-secondary education opportunities of disadvantaged youth. Alternatives are examined on three levels.

1. *Alternative Objectives.* What should be the basic objective of post-secondary education programs for disadvantaged? Objectives discussed include an exit from poverty goal, a labor force growth goal, a personal income goal, and an equality of opportunity goal.

2. *Alternative Ways to Achieve Objective.* What are the broad program directions the State of Wisconsin should be taking in achieving its goal of reducing the number of non-poor in college to poor in college from 3 to 1 to 2 to 1 by 1975? Alternative mixes of resources including public and private resources are evaluated.

3. *Alternative Ways to do Given Jobs.* Which is the most efficient and economical approach once broad program directions have been set?

XVG.2 On a Theory of Accessibility Preference for Selected Neighborhood Services, G. L. PETERSON, Northwestern University, Evanston, Illinois, and R. D. WORRAL, Peat, Marwick, Livingston & Co. 1025 Connecticut Ave., Washington, D.C. 20036.

A theory of individual preference for accessibility to eight selected neighborhood services is developed, based on the concept of a perceived tradeoff between the individual's desire for proximity to the service and his perception of its potential irritant or nuisance value if it is located too close to his home. The theoretical analysis is supported and confirmed by the analysis of data collected in Chicago, Illinois by means of a simple accessibility game.

XVG.3 Toward a Metric for Evaluating the Impact of Urban Highway Construction on Neighborhood Structure, R. D. WORRAL and R. ELLIS; Peat, Marwick, Livingston and Co., 1025 Connecticut Ave. N. W. Washington, D.C. 20036, and G. L. PETERSON, Northwestern University, Evanston, Ill.

A method is presented for evaluating the impact of alternative urban highway alignments on neighborhood structure, based on the concept of the highway's disruptive effect on household activity patterns. Activity patterns are measured analytically. A simple heuristic is then presented for computing and evaluating the effect on this pattern of specific highway alignments, leading to the development of an optimal route location model set in the format of a linear program.

XVG.4 Survey of Changing Trends In Social Institutions, ROBERT W. KNAPP, Associate Professor of Business Administration, School of Business Administration, University of Colorado, Colorado Springs Center, Colorado Springs, Colo. 80907.

This non-mathematical paper attempts to survey and summarize about six or eight recent major books devoted to analyzing and predicting future trends in our politico-economic system. The focus will be on the likely changes in (1) social institutions, (2) business-government relations and (3) the balance in our pluralistic society. Also, emphasis will be on the forces in society that will likely produce these institutional changes.

XVG.5 Structuring and Dimensioning Urban Activity Models, EDWARD F. SULLIVAN, TriState Transportation Commission, 100 Church St., New York, N.Y. 10007.

Urban activity sub-systems include: metropolitan economy; population; land use; utilities, transportation; and social systems. They involve many interrelated variables, definable and measurable in various ways, complicated by dimensions of time and geography. Sufficient observations are usually expensive, placing a premium on structural simplicity and economical measurement. Definition of objectives is complicated by diverse decision making processes.

This paper reviews the state of development of urban system models, and examines opportunities for new developments and for interrelating separate models. The adequacy of currently available data is examined in relation to management of urban systems.

XVH.1 Lunar Traverse Geophysics in the Post-Apollo Time Frame, JOEL S. WATKINS, University of North Carolina at Chapel Hill, Chapel Hill, N.C. 27514.

Extended stay times and the availability of vehicles in the Post-Apollo time frame will permit sophisticated geophysical studies which are not possible during the Apollo missions. Gravity traverses, explosion seismology experiments and array measurements of seismic and electrical properties of the moon will vastly improve our knowledge of the interior of the moon.

XVH.2 Electromagnetic Experiments at the Lunar Surface, J. B. ARNETT and G. C. HENDERSON, General Dynamics, Fort Worth Division, P. O. Box 748, Fort Worth, Texas, 76101, and A. A. J. HOFFMAN, Texas Christian University, Fort Worth, Texas 76129.

An ongoing study is directed toward the establishment of a passive electromagnetic experiment on the lunar surface which should yield information about the electrical properties of the lunar interior. Magnetotelluric methods would be applied to interpret these electric and magnetic field measurements of frequency less than 1 Hz.

Model calculations have been undertaken to obtain estimates of the magnitudes of the fields at the lunar surface due to incident hydromagnetic-waves. Results of laboratory experiments to determine the resistivity of simulated lunar material are applied to the problems of electric field measurement and lunar resistivity experiments.

XVJ.1 Astronaut Dynamics, J. ROBERT TEWELL and CHARLES H. JOHNSON, Systems Research Department, Martin Marietta Corp., Denver, Colo. 80201.

This paper presents the results of an effort to generate a mathematical model of man for space program applications where the disturbance effects of astronaut motions must be considered, e.g., in the design of attitude control systems, or the development of space experiments such as laser communications and stellar astronomy.

The dynamic equations are developed and the resulting mathematical model verified by direct comparison of test subject generated dynamic disturbances.

XVJ.2 Maneuvering Unit Comparison, Maj. C. E. WHITSETT, JR., Principal Investigator, AAP Experiment M509, NASA Manned Spacecraft Center, Houston, Texas 77058, and ALLWIN E. WUDELL and WILLIAM H. TOBEY, Systems Research Department, Martin Marietta Corp. Denver, Colo. 80201.

This paper describes two studies on the comparison, through simulation, of three maneuvering units: An unstabilized Astronaut Maneuvering Unit (AMU), a Hand Held Maneuvering Unit (HHMU), and an Integrated Maneuvering and Life Support System (IMLSS).

Martin Marietta Corporation's Space Operations Simulation facility was used for the study. The simulation technique involves computation of the problem dynamics on a hybrid computer which then determines the commands for the moving base.

XVJ.3 Orbital EVA, KENNETH SHEFFIELD, Flight Technology Department, Martin Marietta Corp., Denver, Colo. 80201.

This paper presents the problems associated with EVA and traces the associated technology through the planned Apollo Applications Program EVA's. A Description of the EVA tasks planned for the future, the problems they generate and the solutions proposed for these problems is presented.

XVIA.1 Safety for Large Space Stations, *JACK W. WILD, Director, Mission Planning and Operations, Advanced Manned Mission Programs, NASA, Washington, D.C. 20546.*
 NASA safety studies which have been accomplished over the past several years and the impact of these studies on the evaluation of space station safety concepts are reviewed.

The safety problems associated with large space stations are discussed and ultimate approaches to solutions of the anticipated problems are presented. The approaches discussed include damage containment and control techniques, escape concept, Earth-base rescue and possible combinations of the foregoing advantages and disadvantages of the approaches presented are examined in terms of cost and technical concepts of specific areas in which additional information should be developed or highlighted.

XVIA.2 Safety Technology Support for Large Space Stations, *I. I. PINKEL, Director, NASA Safety Information and Research Center, Lewis Research Center, Cleveland, Ohio 44135.*

The approach to safety for advanced spacecraft requires detailed technology due to the complexity of the systems. There are seldom simple solutions to the safety problems. The technological support will have to be explored in considerable detail to provide the required level of safety.

XVIA.3 Looking Ahead. Unmanned Spacecraft Systems Safety, *L. C. MONTGOMERY, Staff Engineer, Jet Propulsion Laboratory, Pasadena, Calif. 91143.*

This paper describes systems safety concern for unmanned spacecraft. Given, are the safety concerns for past and present spacecraft and extrapolation of this information into those crafts predicted for the foreseeable future.

XVIA.4 System Safety for Astronaut Maneuvering Units, *GEORGE B. MUMMA, Martin Marietta Corp., Denver Division, Denver, Colo. 80201.*

This paper discusses the design criteria/standards which must be applied to support the development of Astronaut Maneuvering Units. These maneuvering devices, which will be necessary for the support of large space stations, will subject the astronaut to hazards if proper safeguards are not incorporated during the design activity. The paper discusses deficiencies in existing criteria to meet the new challenge.

XVIA.5 Advanced Systems Safety, *PHILIP H. BOLGER, Deputy Director, Manned Space Flight Safety Office, NASA, Washington D.C. 20546.*

The paper discusses the requirements of the Manned Space Flight Safety Office for crew training and certification, Manned Flight Awareness Activities, Man-Rating Techniques, Hazard Analyses, etc. These requirements will be reviewed for their adequacy for future large space stations. Problem areas requiring work by System Safety personnel will be outlined.

XVIB.1 The Role of Nitrogen Oxides from Automobiles in Smog, *RICHARD D. CADLE, Head, Chemistry and Microphysics Department, National Center for Atmospheric Research, Boulder, Colo. 80302.*

Nitrogen oxides are particularly important in the formation of photochemical smog, which is characterized by the presence of undesirable materials formed by the action of sunlight on a mixture of organic compounds, oxides of nitrogen, and air. When first emitted to the

air, the oxides of nitrogen consist largely of nitric oxide but in photochemical smog the nitric oxide is rapidly converted to nitrogen dioxide, which, in turn, absorbs sunlight and triggers the chemical reactions that produce smog. They also participate in reactions forming objectional organic nitrogen compounds. Various methods for preventing the formation of the oxides of nitrogen by "fixation" are discussed. Finally, the question of the extent to which pollution must be reduced in a given urban region so that it might be apparent is considered.

XVIB.2 Follow the Leader--To Pollution Control, *Keith J. SCHIAGER, Director, Environmental Health Services, and Associate Professor of Radiation Biology Colorado State University, Ft. Collins, Colo. 80521.*

Stringent limitations on the acquisition, use and disposal of radioactive materials have contributed to the unique safety record and good public relations of the nuclear industry. At the present time, radioactivity is more closely controlled than almost any other category of toxic materials. However, the proliferation of the types and quantities of radioactive materials requiring disposal indicates that even the current restrictions may be inadequate in years to come. Some new concepts for waste management are discussed. Although radioactive wastes are used as illustrations, the concepts are applicable to a wide variety of waste materials.

XVIB.3 The Restoration of Natural Waterbodies, *HAROLD ANTHONY, Senior Quality Engineer, and GEORGE P. FULTON, Manager, Quality and Test Engineering, Martin Marietta Corp., Denver Division, P.O. Box 179, Denver, Colo. 80201.*

Man pollutes his natural waterbodies because he has upset the natural equilibrium and rendered the natural restoration process effectively inoperative.

A theory is offered whereby the natural restoration process can be either enhanced substantially or completely rejuvenated. This theory involves the process of direct oxygen gas insertion into natural waterbodies.

XVIB.4 Denver's Pollution Problems, *WAYLAND J. WALKER, Environmental Planner, Denver Regional Council of Governments, Denver, Colo. 80211.*

The air, water and land pollution situation in the Denver Area is not going to improve if we allow complacency and the status quo to hold forth.

The Denver area *air* pollution that originates from automobiles, steam plants and industrial sources continues to increase in the five county region.

The land pollution as evidenced by local auto-body disposal practices, inadequate sanitary landfill and waste disposal procedures, and piecemeal environmental administration continues to plague the area.

The condition of the water in the South Platte and its tributaries as they course through Denver remains critical, intolerable, and much remains to be done to correct the situation.

XVIB.5 Industry's Role in Air Pollution Abatement Programs, *LLOYD T. JENSEN, SR. Vice President, The Great Western Sugar Company, P. O. Box 5308, Denver, Colo. 80217.*

Industry finds itself in a paradoxical situation with mounting pressures on air pollution abatement and insufficient technical information to solve the problems in many areas.

The cost of acquisition of technical information and the installation costs of the physical facilities for air quality control may bring economic problems on industry that will create inequities. Movement of industries from urban centers will not solve the cities' financial and social difficulties.

XVIB.6 An Evaluation of the Use of Systems Analysis to Solve a Waste Management Problem, *IRWIN PRICE and DAVID H. STIMSON, University of California, Berkeley, Calif. 94720.*

In this paper an evaluation of a completed study "A Systems Study of Solid Waste Management in the Fresno Area," is presented.

Success in space exploration and weapon development has led some public administrators to consider using the "systems approach" of aerospace companies to solve pressing social problems. These administrators hope that whatever systems analysis is, it can help them.

The Fresno waste management study is evaluated in terms of the criteria selected, model developed, alternatives considered, variables included, and procedures used for quantifying the variables, for handling the political aspects, and for implementing the recommendations of the study. The administrative and economic feasibility of the solution is also considered.

Some general statements about the systems approach to problem solving in the public sector and the kinds of problems most amenable to this approach conclude the paper.

XVIB.7 Regional Air Pollution Analysis, *M. L. FRANKEL, Senior Staff Engineer, TRW Systems, Software and Information Systems Division, Washington, D.C. 20006.*

Regional air pollution control starts with a framework of mathematical simulation and optimization programs combining several diverse studies. Highlighting these studies are the development of pollution emission inventories, statistical evaluation of meteorological data, gaseous transport and diffusion of atmospheric pollutants, control strategies, cost effectiveness of control devices, and the regional economic impact of pollution control. Mathematical models of these analyses have been combined in a simulation program designed to evaluate the effects of legislative pollution emission standards. An optimization program is used to develop a least-total-direct-cost optimality criterion indicating the trend of preferred non-optimal control strategies.

XVID.1 Conditions for Success (and Failure) in OR Applications, *LELAND A. MOODY, Arthur Anderson and Co., Chicago, Ill 60604.*

This paper describes five representative case histories derived from 15 years of consulting experience in the field of Operations Research. A common format is used to evaluate the results of each application. The measurements of results range from "excellent" to "none". By contrasting the circumstances surrounding each of these five situations, conclusions are derived about the conditions necessary for successful implementation of Operations Research results.

XVID.3 Costing Techniques and Models, *THOMAS J. MCCARTHY, Lybrand, Ross Brothers and Montgomery, 60 Broad Street, New York, N. Y. 10004.*

Today's competitive pressures on cost and prices, with a resultant squeeze on profits, makes evident the need for improved management cost estimating systems. Some of the newer methods for estimating and controlling costs will be discussed. These methods include recognition of uncertainty, risk analysis, economic & market conditions. Two models employing the technique of Monte Carlo simulation will be discussed. The case study presented will be in the context of building contracting. The first model is a cost estimating model. The output from the cost estimating model is entered into the second model, a bidding model, which is designed to aid in determining pricing policy.

XVID.4 Scheduling and Forecasting, *RAYMOND J. REISERT JR., Lybrand, Ross Brothers and Montgomery, 60 Broad Street, New York, N. Y. 10004.*

In any business situations, especially those involving new ventures, new products, new markets, etc., insufficient historical data exists to be used as a basis of traditional forecasting methods. With the growing acceptance of mathematical models, as tools in

corporate planning, the need to forecast this nonhistorical behavior becomes crucial. Too often this need has been satisfied through the use of simple single point estimates which of necessity must be wrong. Using probability distributions of estimates not only overcomes the shortcomings of single point estimates, but promotes a risk analysis approach to forecasting. The use of Bayesian methods in a forecasting model, designed to evaluate the profitability of new mail order promotions, will be discussed. The concepts underlying judgemental estimation and the role it plays in forecasting will be elaborated. Techniques of designing feedback mechanisms to refine the Bayesian forecast will also be discussed.

XVIE.1 Attrition Rates for Probabilistic Combat Models, *S. KIMBLETON, Asst. Prof. of Industrial Engineering, University of Michigan, Ann Arbor, Mich.*

Lanchester's original work in mathematically describing the dynamics of combat was deterministic in orientation. Current efforts in this area, however, reflect increasing adoption of the stochastic viewpoint. In this paper, previous work on obtaining probabilistic Lanchester attrition rate coefficients is extended. By using different techniques, a model is obtained which allows statistical verification in terms of easily measurable parameters of the particular weapons system under consideration.

XVIE.2 Evaluation of V/STOL Aircraft In A Multi-Mission Scenario Using Statistical Distributions For Mission Frequencies, *DILIP R. LIMAYE, The Boeing Co., Vertol Division, P. O. Box 16858, Philadelphia, Pa. 19142.*

In the evaluation of V/STOL aircraft which have to perform several different missions, a Measure of Effectiveness and a Cost-effectiveness Index (CEI) are obtained for each aircraft for each mission. The Composite Cost-effectiveness Index (CCEI), which is the evaluation criterion, is then defined as the weighted sum of the CEI's, weighted by the relative mission frequencies. The relative mission frequencies are functions of the aggregate daily mission demands (tons per day, sorties per day, etc.). These mission demands are assumed to be random variables. If the joint distribution of the mission demands is known, the distribution of the CCEI can be obtained by deriving the distribution of the appropriate transformations. This paper examines the uniform, the normal, and the gamma distributions as the underlying distributions for mission demands.

XVIE.3 Graphical Comparison of Cost-Effectiveness In A Multi-Mission Scenario, *DILIP R. LIMAYE, The Boeing Co., Vertol Division, P. O. Box 16858, Philadelphia, Pa. 19142.*

This paper describes methodology developed for a cost-effectiveness comparison of different aircraft configurations using a multi-mission scenario. The technique consists of defining for each of m different missions, an appropriate Measure of Effectiveness (MOE). The values of the MOE are calculated parametrically for several different mission radii and a weighted MOE is obtained for each mission by using a suitable frequency distribution (such as the Beta-distribution) for the radius. The weighted MOE's are divided into the unit cost per aircraft to compute a Cost-effectiveness Index (CEI) for each aircraft for each mission.

A cost-effectiveness comparison is then performed using a graphical approach. The graphical method consists of plotting points whose coordinates represent the CEI's of the aircraft being evaluated and a baseline aircraft. Each mission is thus represented by a point, and the missions define a convex polygon such that all possible combinations of missions are contained within it. If the exact mission mix is known, an appropriate point can be plotted in the polygon to determine which aircraft is more cost-effective. If the exact mix is unknown, but lower and upper bounds are available for mission frequencies, a region of probable mission mixes is obtained. This "critical region" within the polygon provides visibility into the relative cost-effectiveness of the candidate and baseline aircraft, and provides valuable information for the selection of the more cost-effective aircraft. The graphical approach has also been found to be very useful in displaying the impact of varying input parameters in sensitivity analyses.

XVIE.4 Assessment of Weapon System Effectiveness with Combined Monte Carlo—Expected Value Type Simulations, *J. C. STAMPER and G. L. GALLAGHER, General Dynamics, Pomona Division, P.O. Box 2507, Pomona, Calif. 91766.*

The most realistic simulations of weapon system operation in a battle situation are made through the use of Monte—Carlo type simulations which proceed through any engagement on the basis of the time-oriented actions which take place in the real world. The major difficulty with such simulations is that because of the stochastic nature of some of the events, a substantial number of simulated engagements must be run before reasonable confidence is established in the output of such a simulation. In contrast, it is oftentimes considered reasonable to assess through simple expected value models the results from certain classes of weapon system engagements. This paper discusses a technique for combining certain characteristics of both the Monte Carlo and expected value models to yield the realism of the Monte Carlo model and the economy of assessment of the expected value model.

XVIF.1 Optimal System Reliability for an Arbitrary Structure, *RICHARD M. BURTON and GILBERT T. HOWARD, Department of Operations Analysis, U. S. Naval Postgraduate School, Monterey, Calif. 93940.*

The paper considers a generalization of the optimal redundancy problem. We consider an arbitrary network consisting of series and parallel connections of N modules. The objective is to maximize the system reliability subject to cost, weight, or volume constraints. The paper differs from others in that we permit modules in logical parallel to be of different designs, and investment in a module does not imply that redundant components will be used.

This paper recognizes the applicability of dynamic programming to this more general problem. An example is included.

XVIF.2 Application of the Learning Curve to Maintainability Tests and Demonstrations, *ROBERT L. STREET, Industrial Engineering Department, Texas A&M University.*

In most procurement situations where maintainability requirements have been specified, the method of demonstrating compliance with these requirements involves measurement of performance by a specially selected maintenance technician or maintenance team.

A method is proposed in this paper whereby the factor of learning may be included in the usual maintainability demonstration plan. Approaches are proposed to refining the method and thereby providing for more precise techniques of predicting maintainability in new system designs as well as allowing development of more precise and meaningful maintainability requirements.

XVIF.3 On-Line Reliability Concept, *JOHN P. HORNING, Technical Operations, Inc., Burlington, Mass.*

The On-Line Reliability Concept was developed as a technique to provide a means of reducing system downtime required for locating malfunctioning equipment and/or determining the operational status of complex hardware systems.

This paper presents the overall concept and methodology of the On-Line Reliability System. It also contains the description and results of a feasibility model that was developed for the purpose of testing the system's statistical sampling and hardware simulation techniques.

XVIF.4 Two Simulation Models For Planning And Evaluating Aircraft Avionics Maintenance Systems, *ALAN P. FEDDERSEN, University of California, Irvine, Calif.*

This paper describes two simulation models developed to aid in the planning and design of aircraft avionics maintenance systems. A key variable for measuring avionics effectiveness is

availability, that proportion of time that an avionics system is in an up state. Availability is seen as a function of the avionics system reliability and maintainability.

Aircraft maintenance may occur hierarchically at the flight line (plane-side), at the field shop, and at one or more depots. These two complementary models allow analysis of aircraft availability in terms of variable system reliability (depicted by several state-of-the-art system designs) and system maintainability (depicted by varying design concepts and differing maintenance philosophies). The first model focuses attention on aircraft operation and flight line maintenance, the second model on various field shop and depot maintenance schemes.

In addition, the problems associated with the ultimate use of such complex simulation models are discussed.

XVIG.1 A Stochastic Model for the Analysis of Epidemics, *MICHAEL E. THOMAS, Industrial and Systems Engineering Department, University of Florida, Gainesville, Fla.*

In this paper we develop a stochastic model for the prediction of the spread of certain types of epidemics through the population of a relatively closed system. The development of this model was initiated with the intent of evaluating various decision policies which might be adopted to combat the spread of the disease.

The characteristics of the particular disease under consideration are: (1) the entire population is susceptible to the disease, and (2) each person who contacts the disease passes through three phases and the length of each of these phases is a random variable. The relevant characteristic of the system is that the population mixes uniformly.

The analysis leads to some interesting and unusual conclusions regarding the alternatives proposed. The conclusions as well as some experimental problems will also be discussed.

XVIG.2 An Information System for State Health Planning, *W. R. BRIAN CARUTH, Mgr. Operations Research, Southwest Research Institute, San Antonio, Texas 78206.*

Comprehensive health care is a relatively new concept in the field of public health.

The objective of comprehensive health care is to provide complete and total medical care tailored to the individual and to the community, with emphasis on preventive health measures and guidance in family planning, and in family and community living.

Traditionally public health programs have been segregated and administered by a number of different state agencies. Consequently, the collection, storage and dissemination of public health data has been fragmented and diffuse.

The paper describes a study undertaken to develop a health planning information system to provide the integrated and coordinated data that are required for effective comprehensive health care program planning and evaluation.

XVIG.3 Planning and Analysis for Higher Education—Promises and Pitfalls, *PAUL W. HAMELMAN and J. DOUGLAS MACHESNEY, West Virginia University.*

Public expenditures for higher education have risen sharply in the last decade and are projected to increase further in the decade 1970-80. In large measure, this increase is attributed to the liberal financial support given public institutions by individual state legislatures and the rapid growth of state colleges and universities in terms of enrollments and resources. This paper discussed educational planning and analysis at the state level of consideration.

Operationally and conceptually, state higher education planning lies at a point between

global planning models which display methods of determining optimum resource allocations to the higher education sector of a national economy (epitomized by studies undertaken by OECD) and micro models describing methods of effective resource allocation within a specific institution of higher learning. Existing models provide valuable points of reference for state higher education planning, but must be modified to accommodate issues peculiar to this level of analysis.

XVIG.4 An Assessment of the Contribution of Operations Research to Educational Planning, *HAROLD WEITZ, Advanced Systems Development Division, IBM Corporation, 2651 Strang Boulevard, Yorktown Heights, N. Y.*

During recent years, the methods of operations research and systems analysis have been increasingly applied to problems of education. The developments to be considered fall into the categories of: a) systems analysis and educational research, b) program planning and budgeting, c) system planning models, d) gaming for instruction and administrative training, e) systems approach to design of instructional systems and f) the evaluation of computer systems for information and instruction.

Major emphasis will be given to identifying the emerging pattern of educational system planning model development: 1) projection of enrollment populations, 2) structuring of resource requirements, 3) rules for allocation and assignment of resources, and 4) evaluation.

XVIG.5 Joint Production and Cost Functions for a Big City High School System, *THOMAS G. FOX, The Pennsylvania State University.*

In order to conduct the analysis, data on school system inputs and outputs is available from an earlier study by the author for each of the Chicago high schools. Differences among socioeconomic groups attending the high schools—exogenous variables—are recorded from Census data carefully fit into mutually exclusive high school attendance areas.

XVII.1 Application of Bayesian Decision Theory to Large Fire Control Systems, *JAMES B. DAVIS, Forest Fire Laboratory, U. S. Forest Service, Riverside, Calif.*

More than 1.1 billion acres of forested land within the continental United States, Alaska and Hawaii require protection from fire. Each year from 100,000 to 175,000 fires occur on these lands. Each major fire presents a unique systems design problem involving a sequence of decisions made under conditions of uncertainty.

This paper discusses the compatibility of Bayesian decision theory for integrating various system inputs. It also discusses the value of information as a function of environmental uncertainty, pay-off utility, and nature of the information for the modification of fire control tactics, strategies and policies.

XVII.3 Subjective Measures of Merit Involving Multiple Criteria of Evaluation, *LEE H. SMITH, The University of Texas, Arlington, Texas.*

The situation frequently arises where it is necessary to repeatedly choose between two or more alternatives when multiple criteria of "merit" are involved. In such cases, the decision-maker often has to rely on subjective evaluations in order to reach a decision. A method is described which allows consistent development of a subjective "measure merit" or an "index of merit" to be used in rating or ranking "systems" with respect to several characteristics at a time. Of notable importance is the fact that the procedure is applicable to the situation where part of the system characteristics are measurable on a universally familiar objective scale and part are measurable only on a subjective scale.

XVII.4 A Non-Stationary Probability Diffusion Model for Consumer Brand Choice Behavior, *J. MORGAN JONES, Asst. Prof., Graduate School of Business, UCLA.*

A recent controversy has arisen in models of consumer brand choice behavior. The

question centers upon whether the change in predisposition toward a certain brand is due to an external influence or to purchase event feedback. In an effort to solve this controversy, a non-stationary probability diffusion model is proposed. Many useful and interesting properties of the model can be derived and compared with corresponding properties from models previously proposed. Although the model was conceived in a marketing context, it would appear to be valuable in studying many types of adaptive human behavior in a dynamic situation.

XVIK.1 A Methodology to Compare Policies for Exploring the Solar System, ROBERT G. CHAMBERLAIN, and LOUIS KINGSLAND, JR., *Jet Propulsion Laboratory, Pasadena, Calif. 91103.*

This paper describes procedures to process part of the information effecting decisions about unmanned exploration of the solar system. Specifically, the contributions of proposed sequences of missions toward achieving the primary scientific objectives of exploring the solar system are determined. Since portions of the scientific objectives may be fulfilled (or preempted) by the space exploration programs of other nations, several foreign space programs are assumed as background to provide further insight into wisdom of alternative decisions.

XVIK.2 Planning Future Information Transfer Missions, EDGAR M. VanVLECK, *Research Scientist, Special Projects Office, NASA Mission Analysis Division, Moffett Field, Calif. 94035.*

Both the demand for information transfer and the technology available to meet this demand are increasing beyond our current capability to solve the non-technical problems created. Ideally, an orderly sequence of new systems developments to exploit the technology, and thereby satisfy the demand, should result.

Specific areas in which systems engineering techniques or approaches might aid in solving problems identified in development progressions are discussed. In addition, the paper explores possible effective technology planning for future missions within the context of possible economic, social, and regulatory constraints.

XVIK.3 The Challenge of Providing The Public With Economical Space Transportation by the Year 1980, HENRY G. EDLER, *Professional Staff Member, National Space Council, White House Mail Room, Washington, D. C. 20502.*

This paper deals with the question of what steps must now be taken by our space leaders in order to effect a vigorous and economically potent space program for the early 1980's. It is the author's opinion that the space program activities and budgeting will decline towards a minimal level of effort in the near future if its economics are not projected towards a financially self-sustaining endeavor. The policy, plans, and programs adopted in the next few years will determine what programs implemented in the '70's could pave the way for such economic payoff in the '80's.

Society Affairs

MINUTES OF THE ORSA COUNCIL MEETING

The 34th Meeting of the Council of the Operations Research Society of America convened on 6 and 7 November 1968, in the Sheraton Hotel in Philadelphia, Pennsylvania, with Joseph H. Engel, President, presiding. The following items from the Council Meeting are reported. (Complete minutes can be obtained from the Secretary of ORSA.)

FUTURE ORSA MEETINGS:

No.	Dates	Location	General Chairman
36	November 10-12, 1969	Miami Americana Hotel	M. E. THOMAS <i>Industrial and Systems Engineering Department University of Florida Gainesville, Florida 32601</i>
37	April 20-22, 1970	Washington, D. C. Hilton Hotel	H. M. BERGER <i>OASD (SA)—The Pentagon Washington, D.C. 20301</i>
38	October 28-30, 1970	Detroit Statler-Hilton Hotel	R. C. JELINEK <i>Department of Industrial Engineering University of Michigan Ann Arbor, Michigan 48104</i>
39	May 5-7, 1971	Dallas Hotel Sheraton	R. L. GUE <i>Computer Sciences Center Southern Methodist University Dallas, Texas 75222</i>
40	November, 1971	Los Angeles	G. L. HOLLANDER <i>Hollander Associates P.O. Box 2276 Fullerton, California 92633</i>
41	April, 1972	New Orleans	J. L. BALINTFY <i>Graduate School of Business Tulane University New Orleans, Louisiana 70118</i>

NOMINATIONS: The following slate has been announced by the Nominating Committee:

Vice President/President-Elect

WALTER E. CUSHEN, GEORGE E. NICHOLSON, JR.

Secretary

ROBERT E. MACHOL

Treasurer

KENNETH W. YARNOLD

Council (Two to be elected)

JACK R. BORSTING, GEORGE J. FEENEY, DENOS C. GAZIS,
CLAYTON J. THOMAS

IFORS: The U. S. has been allotted a delegation of 100 to the conference in Venice, June 23-27, 1969. ORSA will co-sponsor a meeting with ORSIS (the Israel OR Society) during the first week of July.

PUBLICATIONS: The Cumulative Index for the Journal, *Operations Research*, has been completed and will be published during 1969. Paul Gray was appointed acting editor of the *Bulletin*.

EDUCATION COMMITTEE: The Committee has prepared a brochure, "Careers in Operations Research". 15,000 copies of this brochure will be printed. The first year of the lectureship series has been successfully completed, with requests for 20 lecturers filled. Since aid from an NSF grant is anticipated, this program will be expanded next year.

LANCHESTER PRIZE: The Council approved the award of the Lanchester Prize to Douglass J. Wilde and Charles S. Beightler for their book, *Foundations of Optimization*, published by Prentice-Hall, Inc. The report of the Lanchester Prize Committee is appended.

SECTIONS: The Council raised the Technical Sections service charge from \$1.00 to \$2.00. A petition was presented by J. Ravennis to form a San Diego section. This was approved, subject to approval of the Constitution by the Chairman of the Sections Committee. The Case Western Reserve Section was also approved.

BUDGET: The membership having approved a change in by-laws raising dues for U. S. and Canadian Members to \$15.00, the Council established foreign dues at \$13.50, student dues at \$8.00, Journal subscriptions at \$12.50 domestic, and \$13.50 foreign. It was anticipated that these steps would halt the present deterioration of the financial position of ORSA. A financial committee consisting of Caywood, *Chairman*, Yarnold, Nicholson, and Brigham, was appointed by President Engel to consider the financial aspects of ORSA, including further reductions of expenditures, further increases of dues, or both.

MEMBERSHIP: As of 30 September, there were 2213 Members, 4433 associate members, and 753 student associate members, for a total membership of 7399.

NEW MEMBERS: The Membership Committee reported its nominees for full membership in the Society. The following were elected by the Council as new Members:

Abert, James G.
Adiri, Igal
Agin, Norman I.
Archer, William L.
Ardley, Harry M.
Arwine, William C.
Astor, Raymond J.
Baker, Norman R.
Bandyopadhyay, Rangalal
Bayraktar, Bulent A.
Bercaw, Woodson W., Jr.
Blackmore, W. Russell
Blanchard, Benjamin S.
Boisseau, Henry J., Jr.
Bossenga, John R.
Boulard, Heber, D.
Bratt, Bengt E.
Brewer, George W.
Bruce, Charles A., Jr.
Bujosa, Andres
Bunker, William B.
Burlew, John S.
Carol, Arthur
Cartaino, T. Francis
Caruth, Wildridge B.
Chatterjee, Samprit

Chilsolm, Henry J.
Churchill, Robert E.
Collison, William F.
Connolly, Thomas W.
Culbertson, Denny D.
Curtis, William H.
Dahl, Olof
Dale, Lawrence P.
Debanne, Joseph G.
Devanney, John W.
DeWald, Charles
Donnelly, Norman J.
Dunlap, Lloyd L.
Dwyer, James J.
Eckles, James E.
Emlet, Harry E.
Ezell, Dee Earl
Feng, Hwa-Tsun
Fernald, Philip F.
Fields, J. Frank, Jr.
Finkelstein, Jay L.
Fowler, Charles W.
Frost, Cecil R.
Furman, Gershon G.
Galiano, Robert J.
Giglio, Richard J.

Glueck, Charles G., Jr.
Hall, John R.
Hirschberg, David
Hirschmann, John F.
Holdsworth, John R.
Hollander, Gerhard L.
Horn, John Howard, Jr.
Hornung, John Philip
Huebsch, Ian O.
Isaacson, Robert T.
Jantzen, Milton D.
Kaczka, Eugene E.
Kelley, Albert L.
Kennedy, Miles H.
Kessler, Martin D.
Kowalik, Janusz S.
Kyle, Thomas N.
Lerner, Eugene M.
Lester, Dick McConico
Letts, Roger William
Louer, Philip Edward
Levien, Roger E.
Levy, Paul S.
Losch, Emil Galilaus
Mackenzie, Kenneth D.
Mahar, Thomas A.

Mangasarian, Olvi L.
 Matula, David William
 Mjosund, Arne
 Morrill, Ralph A.
 Myers, Keith A.
 Neider, Ferdinand V.
 Nezer, Marc M.
 Noah, Joseph Watson
 Nunn, Geoffrey E.
 Oslake, Jack J.
 Paskman, Martin
 Pasquali, Janis Marie

Perks, Norman W.
 Perry, William H.
 Popper, Robert D.
 Reiter, Stanley
 Robertson, James L.
 Rosen, Frederick K.
 Rosenthal, Myron R.
 Rydzewski, James C.
 Sanders, Jerry Lee
 Sasmor, Robert M.
 Saunders, Sam C.
 Sax, Franklin S.

Saylor, David
 Simms, Joseph
 Stasch, Stanley F.
 Stephenson, George G.
 Tater, William M.
 Taylor, Vincent D.
 Tholen, Albert D.
 Thompson, Howard E.
 Wallace, Edward L.
 White, Leon S.
 Wilkinson, John C.
 Williams, Robert L.

MINUTES OF THE 1968 ANNUAL BUSINESS MEETING

The Sixteenth Annual Business Meeting of the *Operations Research Society of America* was convened at the St. Francis Hotel, San Francisco, California, on 1 May 1968, with JOHN E. WALSH, *President*, presiding.

The Minutes of the Fifteenth Annual Business Meeting were approved as printed in the Fall 1967 issue of the *Bulletin* (p. B-267).

The Report of the Treasurer was approved as printed in the Spring 1968 issue of the *Bulletin* (p. B-183).

On behalf of the Tellers, A. Rubenstein and G. Rath, the Secretary announced the results of the election of Officers and Council Members.

Vice President/President-elect
Secretary
Treasurer
Council Member
Council Member

THOMAS E. CAYWOOD
 ROBERT E. MACHOL
 KENNETH W. YARNOLD
 CHARLES D. FLAGLE
 DAVID S. STOLLER

The President declared this slate elected, and then invited the incoming *President*, JOSEPH H. ENGEL, to take the chair.

President Engel then invited retiring *President* Walsh to present his report.* Dr. Walsh also thanked retiring committee chairmen for their past services: Clinton J. Ancker, Long Range Planning Committee; Robert Braswell, Meetings Committee; George Morgenthauer, Nominating Committee; Kenneth W. Yarnold, Membership Committee; Herbert Galliher, Editor of *International Abstracts in Operations Research*; Thomas E. Oberbeck was thanked for his past services as Treasurer, and for accepting the appointment as Chairman of the Long Range Planning Committee.

The President called for any items of old or new business. There were none.

The meeting adjourned.

ROBERT E. MACHOL
Secretary

REPORT OF THE COMMITTEE FOR THE 1967 LANCHESTER PRIZE

The Committee for the 1967 Lanchester Prize followed the same procedure that was used the preceding year and issued a call for nominations that was inserted in the Spring issue of the *Bulletin*. This call brought 21 nominations of 14 different items representing

*Printed in the Fall 1968 issue of the *Bulletin*.

Society Affairs

papers and books published in 1967. All of these items were carefully screened by the Committee.

The Committee unanimously recommends that the prize be awarded to the authors of the book, *Foundations of Optimization*, by Douglass J. Wilde and Charles S. Beightler, published by Prentice-Hall, Inc. This book is recommended because of the marked degree with which it meets the following two of the stated criteria for judging prizeworthiness:

- The degree of unification or simplification of existing OR theories or methods that it achieves.
- Expository clarity and excellence.

This book, for the first time, presents in one volume the wide range of optimization techniques that have been proposed in the literature, together with an extensive and valuable bibliography. The writing is lucid and meticulous, and the exposition and format are very good. The volume fills a real void in the expository literature.

JOHN F. MAGEE

PAUL J. WILLIAMS

GEORGE SHORTLEY, *Chairman*

Editor's Note—Douglass J. Wilde is Professor of Chemical Engineering at Stanford University and Charles S. Beightler is Professor of Mechanical Engineering at the University of Texas. The prize was formally presented to Professor Wilde at the business meeting of the Society on November 7, 1968.

THE FUTURE OF THE BULLETIN

In perusing this issue of the *Bulletin* you no doubt noticed a number of changes from previous issues. These changes (in type face, type size, maximum length of abstracts, format of the program) were all made in the interests of economy.

For the year ending September 30, 1968, the *Bulletin* cost the Society approximately \$6,000 net, or approximately \$1 per member. At the 35th National Meeting in Philadelphia last November, the Publications Committee decided that the time had come to reassess the role of the *Bulletin* and to institute economies in its publication. To provide the membership with an opportunity to express its wishes, the Committee decided that this issue and the next one would continue the past pattern, but with economies in production.

The present view of the *Bulletin* is that it is a formal publication containing information of both permanent and transient interest. As such, it is bound and printed in a form suitable for permanent storage in libraries. It has been argued by some that the abstracts of talks at meetings of the Society are really of short-term interest because the contents of worthwhile talks eventually are incorporated in papers published in the *Journal* or elsewhere, whereas records of poor talks should be allowed to drift into genteel obscurity. The News and Announcements section, of course, is concerned with current information, although severely limited by the semiannual publication cycle. The Society Affairs section is a permanent record, but one that need not be kept by all members.

A number of suggestions have been made for change. These include:

1. Increasing the frequency of publication to four or six times a year to include additional and more current news items.
2. Incorporating Technical Section Newsletters in the *Bulletin*.
3. Allocating a fractional portion of Society membership fees to the *Bulletin* and/or charging a subscription fee.
4. Restricting the format and printing process to a simple handout which need not be designed for permanent retention.

We would appreciate receiving your views prior to or at the June meeting in Denver to aid the deliberations of the Publications Committee. It is hoped that there will be a lively discussion at that time and that the Publications Committee will make recommendations to the Council of the Society for action at the November meeting in Miami. Comments may be addressed to the Chairman of the Publications Committee, R. M. Oliver, 235 University Hall, University of California, Berkeley, California 94720, or to the Editor of the *Bulletin*, Paul Gray, Stanford Research Institute, Menlo Park, California 94025.

TREASURER'S REPORT

Santa Monica, California
21 March 1969

The following Balance Sheet for the Society represents the first definitive figures on our financial affairs, being the first to be based on Accrual Accounting methods instead of Cash Receipts, Disbursements and Major Obligations. This wise change was made by Thomas E. Oberbeck a year ago, towards the end of his term of office as Treasurer. The Accrual method has demonstrated what had merely been a belief before, that the Society was losing money rapidly.

As you will remember, the Council took all of the measures within its powers to reduce the expected loss during 1968, while being well aware that major reductions in loss would not be possible. By and large the Balance Sheet before you agrees well with the estimates we made in June of last year. You will remember that, at our business meeting in Philadelphia in the fall of 1968, the Society raised its dues to the minimum level which the Council believed would stop the losses the Society was experiencing. At our next Business Meeting, in Denver, I shall endeavor to present forecasts for 1969. It is too early to say what these will show.

KENNETH W. YARNOLD
Treasurer

AUDITOR'S REPORT

The Operations Research Society of America
Baltimore, Maryland

We have examined the balance sheet of The Operations Research Society of America as of December 31, 1968 and the related operating statement for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

Effective January 1, 1968, the Society changed its basis of reporting from the cash to the accrual basis; accordingly, for the first time the financial statements include a Balance Sheet and an Operating Statement presented in accordance with generally accepted accrual basis accounting principles. Previously, financial statements consisted solely of a statement of cash receipts and disbursements.

In our opinion, the accompanying financial statements present fairly the position of The Operations Research Society of America at December 31, 1968, and the results of its operations for the year then ended, in conformity with generally accepted accounting principles.

LYBRAND, ROSS BROS. & MONTGOMERY

Baltimore, Maryland
March 18, 1969

THE OPERATIONS RESEARCH SOCIETY OF AMERICA

BALANCE SHEET December 31, 1968

ASSETS

Demand deposits	\$ 91,494	
Deposits with federal savings and loan associations and bank	102,694	
Petty cash funds	2,430	
Accrued income receivable	11,797	
Advances	<u>1,400</u>	
Total assets		<u>\$209,815</u>

LIABILITIES AND MEMBERS' EQUITY

Accounts payable	1,334	
Accrued expenses payable	44,447	
IFORS Proceedings funds	5,250	
Third International Symposium, T.S.S.	986	
Deferred dues and subscriptions	<u>99,822</u>	
Total liabilities		<u>151,839</u>

Contingent liability (Note 3)

Members' equity:		
Regular fund	44,961	
International abstracts in OR fund	<u>13,015</u>	
		<u>57,976</u>

Total liabilities and members' equity	<u>\$209,815</u>
---------------------------------------	------------------

See accompanying notes.

OPERATING STATEMENT

for the year ended December 31, 1968

	Regular Fund	International Abstracts in OR
Revenue.		
Dues	\$ 23,332	\$16,441
Subscriptions earned	79,185	17,942
Bulletin advertising	2,584	
Directory net advertising	657	
Journal advertising	18,513	
Technical section fees	4,943	
Mail list sales	11,994	
Sale of back and single issues	1,687	1,053
Royalty income	1,155	
Interest income	4,421	1,373

	Regular Fund	International Abstracts in OR
TRANSPORTATION SCIENCE	12,779	
Publications in OR	1,994	
Meeting income	2,063	
Miscellaneous income	171	
Total Revenues	165,478	36,809
Expenses, as annexed	197,423	39,450
Excess of expenses over revenue	31,945	2,641
Members' equity:		
Balance January 1, 1968	76,906	15,656
Balance December 31, 1968	<u>\$ 44,961</u>	<u>\$13,015</u>
Expenses:		
Directory printing	\$ 4,426	
Bulletin printing	10,575	
Journal printing	72,076	\$28,016
Managerial service	34,837	2,052
Editorial expenses — Editor	6,331	
— Managing Editor	2,982	
— Other	185	
Salaries		4,093
15 year index	4,000	
Advertising commissions	3,186	
Back issues of IAOR for ORSA members	1,953	
Mail list maintenance	2,897	
Mail list expense	1,170	
TRANSPORTATION SCIENCE	22,848	
Publications in OR	4,651	
Meetings committees	532	
IFORS dues	1,416	
Auditing	1,000	
Lanchester prize	1,000	
Visiting lectureship program ORSA	2,599	
Brochure expense	857	
Conference Board on Math Sciences	1,000	
Section expenses (Note 2)	7,411	
Committee expenses (Note 2)	1,457	
Officers and representatives (Note 2)	2,329	
Supplies and materials		1,082
Other journal	2,657	3,413
Miscellaneous expense	3,048	789
Total expenses	<u>\$197,423</u>	<u>\$39,450</u>

See accompanying notes.

NOTES TO FINANCIAL STATEMENTS

Note 1:

The Society has experienced considerable growth over the years which has made the cash basis of accounting inadequate for both internal and external reporting purposes. Consequently, the accrual basis of accounting was adopted as of January 1, 1968.

Note 2:

Details of Section, Committee, and Officers' expenses and Representatives expenses are:

Section Expenses:

Cost effectiveness	\$3,032
Health applications	1,115
Space Science	704
Transportation Science	968
Military applications	1,509
Western section	83
	<u>\$7,411</u>

Committee Expenses:

Sections	591
Publications	53
Education	24
Membership	282
Nominating	378
Lanchester	129
	<u>\$1,457</u>

Officers and Representatives:

Council expense	341
President	583
Vice president	192
Secretary	146
Treasurer	65
IFORS	1,002
	<u>\$2,329</u>

Note 3:

The Society has a guarantee to the publisher of the series "Publications in Operations Research" to purchase and pay for any issues (up to a total of 2,000) remaining unsold after three years. In the opinion of the Council, the Society's total liability under the guarantee is not in excess of \$6,000.

News and Announcements

36TH NATIONAL MEETING

The theme of the Fall meeting of the Society is "Operations Research in Development of Emerging Countries." The meeting will be held November 10-12, 1969, at the Americana Hotel in Miami Beach, Florida.

The theme of the meeting will serve to focus the attention of the members of the Society on the role of operations research in aiding the development of emerging countries. Several sessions have been developed specifically around problems facing those who deal with sociologic and economic problems. The Society has the talent to make meaningful contributions to the solution of problems in the field of health, transportation, education, arms control law enforcement, and economic development. By holding sessions on these important problems, the Society hopes to mobilize its members in bringing their abilities to bear to aid in their solution.

In addition to application areas there will be sessions organized in various technique areas. Specifically, sessions in dynamic programming, integer programming, games, multicommodity flows, and mathematical programming will be held.

A list of the sessions and their chairman are shown below:

- Operations Research in Developing Countries, RUSSELL L. ACKOFF, *Management Science Center, University of Pennsylvania, Philadelphia, Pennsylvania 19104.*
- Theory of Integer Programming, EGON BALAS, *Carnegie-Mellon University, Graduate School of Industrial Adm., Schenley Park, Pittsburgh, Pennsylvania 15213.*
- Operations Research Applications, ROBERT BRASWELL, *Dept. of Industrial & Systems Eng., University of Florida, Gainesville, Florida 32601.*
- Cost Effectiveness Analysis in Safety and Hazard Control, OLIVER BRYK, *Exatech Incorporated, 525 School Street, S.W., Washington, D. C. 20024.*
- Operations Research in Production Planning and Control, JOHN L. COOLEY, JR., *Graduate School of Business Adm., University of Virginia, Virginia Station, Charlottesville, Virginia 22903.*
- Theory of Control, M. M. CONNORS, *Operations Research, IBM, 1930 Century Park West, Los Angeles, California 90067.*
- Theory of Sequencing and Scheduling, RICHARD A. DUDEK, *Dept. of Industrial Engineering, Texas Technological College, Lubbock, Texas 79409.*
- Operations Research in Education, K. A. FOX, *Department of Economics, Iowa State University, Ames, Iowa 50010.*
- Transportation Science, ERNST G. FRANKEL, *Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, Massachusetts 02139.*
- Operations Research in Law Enforcement and Crime Prevention, SAUL I. GASS, *World Systems Laboratories Inc., 7979 Old Georgetown Rd., Bethesda, Maryland 20014.*
- Theory Of Activity Networks, W. W. HAPP, *National Aeronautics & Space Adm., Electronics Research Center, 575 Technology Square, Cambridge, Massachusetts 02139.*
- Theory of Games, RUFUS ISAACS, *Dept. of Operations Research and Industrial Engineering, The Johns Hopkins University, Baltimore, Maryland 21218.*
- Developments In Marketing Simulation, PHILIP KOTLER, *Northwestern University School of Business, Evanston, Illinois 60201.*
- Theory of Mathematical Programming, CARLTON E. LEMKE, *Dept. of Mathematics, Rensselaer Polytechnic Institute, Troy, New York 12181.*
- Methods of Arms Control and Conflict Resolution, J. P. MAYBERRY, *Mathematica, 4905 Del Ray Avenue, Bethesda, Maryland 20014.*
- Operations Research in the Military, GEORGE NICHOLSON, *Statistics Dept., University of North Carolina, Chapel Hill, North Carolina 27514.*
- Airline Fleet Planning, EDUARDO PINA, *Operations Research/Management Sciences, The Boeing Company, P.O. Box 707, Renton, Washington 98055.*

- Operations Research in Health Services, LOUIS PONDY, *Dept. of Business Adm., Duke University, Durham, North Carolina.*
- Utility Theory and Its Applications, G. SUZUKI, *Technical Analysis Division, National Bureau of Standards, Washington, D. C. 20234.*
- Operations Research in Space Science, DONALD TURNER, *National Aeronautics & Space Adm., Code MTE, Room 321, FOB-10B, Washington, D. C. 20546.*
- Theory of Dynamic Programming, ARTHUR VEINOTT, *Dept. of Operations Research, Stanford University, Stanford, California 94305.*
- Theory of Multi-Commodity Flows, ANDREW WHINSTON, *School of Business, Purdue University, Lafayette, Indiana 47907.*

Each session chairman is arranging for invited speakers. Contributed papers are also solicited. In order to provide for more informative discussions, several sessions will be run consecutively in a manner similar to the Seminar sessions introduced at the San Francisco meeting.

The meetings committee urges all members to plan now to participate in this meeting and to contribute to its success by presenting your ideas to your colleges. Abstracts should be sent directly to the session chairman of the relevant session. The abstracts should be limited to 100 words. Authors should indicate if copies of their papers will be available upon request.

Questions or ideas regarding the organization of the meeting should be directed to M. E. Thomas, Department of Industrial and Systems Engineering, University of Florida, Gainesville, Florida 32601. The program chairman is Salah Elmaghraby, Department of Industrial Engineering, North Carolina State University, Raleigh, N. C. 27607. Questions concerning the program or abstracts not related to the fields listed above, should be directed to Dr. Elmaghraby.

37TH NATIONAL ORSA MEETING

The 37th National Meeting will be held at the Washington Hilton Hotel in Washington, D. C., on April 20-22 of 1970. The theme of the meeting will be "Operations Research on Government Problems." Concurrent sessions of invited papers will be held. Contributed papers will be presented in the seminar style introduced at the San Francisco meeting in May 1968. Each author of a contributed paper will be provided with a table, chairs, and a blackboard. For a full session (normally three hours) he may discuss his paper with all comers, or schedule repeated presentations, as he wishes. Inquiries regarding the program should be addressed to Dr. Saul Gass, World Systems Laboratory, Inc., 7979 Old Georgetown Road, Bethesda, Maryland 20014. Inquiries on other matters should be addressed to Dr. Howard M. Berger, Acting Deputy Assistant Secretary of Defense (Strategic Programs), Department of Defense, Washington, D. C. 20301.

THE INSTITUTE OF MANAGEMENT SCIENCES MEETING

The American meeting of TIMS will be held on October 1-4, 1969, at the Regency Hyatt House Hotel, Atlanta, Georgia. Sessions will be held in Optimization and Decision Models, Managerial Economics, Behavioral Science in Management, Management Information Systems, Industry and Banking, Marketing, and Government and Public Services. Some sessions will be theory-oriented; others will be more heavily application-oriented. The program will be published in a later edition of TIMS Bulletin. Those interested may obtain information there, or write to E. T. Alsaker, 5255 Kenbrook Way, N.W., Atlanta, Georgia 30327.

GORDON RESEARCH CONFERENCE

On August 18-22, at Holderness, New Hampshire, the Gordon Research Conferences will hold their first Conference on Operations Research and Management Science. Speakers will include:

THOMAS E. CAYWOOD, *Caywood Schiller Associates*
 C. WEST CHURCHMAN, *University of California*
 FRANZ EDELMAN, *RCA*
 GEORGE J. FEENEY, *General Electric Company*
 PETER C. FISHBURN, *Research Analysis Corporation*
 RONALD A. HOWARD, *Stanford University*
 KENNETH KORTANEK, *Cornell University*
 JOHN F. MAGEE, *Arthur D. Little, Inc.*
 HENRY R. RICHARDS, *Daniel H. Wagner Assoc.*
 LOUIS C. SANTONE, *National Bureau of Standards*
 ROBERT M. THRALL, *University of Michigan*

The conferences were established to stimulate research in universities, research foundations, and industry. This purpose is achieved by informal meetings, mornings and evenings, Monday through Friday noon. The afternoons are available for recreation, reading, or participation in discussion groups, as the individual desires. The purpose of the program is to bring experts up to date on the latest developments, to analyze the significance of these developments, and to provoke suggestions concerning the underlying theories and profitable methods of approach.

Attendance—limited to approximately 100 conferees—is by application on the standard form, which may be obtained by writing.

DR. ALEXANDER M. CRUICKSHANK, *Director*
Gordon Research Conferences
Department of Chemistry
University of Rhode Island
Kingston, Rhode Island 02881

Registration fees for the week including room and meals will be approximately \$120. Accommodations are also available for wives and children over 12 years.

OTHER FORTHCOMING MEETINGS

The Editor receives announcements of various upcoming meetings which may be of interest to the Membership. Please contact the indicated persons for further information.

Date	Title	Location	Contact
Jun. 8-20	International Summer School on Integer and Non-linear Programming	Bandol, France	M. A. Mensch, Directeur d'Etudes, GROT-Depot des Equipages, 83 Toulon- Naval, France.
Jun. 16-18	23rd MORS	West Point, New York	W. C. Pettijohn, Vertex Corporation, 10400 Connecticut Ave., Kensington, Md. 20795.

Date	Title	Location	Contact
Jun. 23-24	8th Symposium of the National Gaming Council	Excelsion Springs, Missouri	R. L. Crawford, Booz, Allen Applied Research Inc., 911 Walnut Street, Kansas City, Mo.
Jun. 23-27	IFORS International Meeting	Venice, Italy	Professor Pasquale Saraceno, Consulente Generale Economico, IRI, Via Veneto, 89-00187, Rome, Italy.
Jun. 30-Jul. 4	NATO Reliability Conference	Turin, Italy	Dr. E. M. Scheuer, RAND, 1700 Main St., Santa Monica, Ca. 90406.
Jul. 7-11	NATO Cost-Benefit Analysis Conference	The Hague, Netherlands	Division of Scientific Affairs, NATO/OTAN, Bruxelles 39, Belgium.
Sep. 1-5	NATO Mathematical Models of Manpower Systems	Lisbon, Portugal	Division of Scientific Affairs, NATO/OTAN, Bruxelles 39, Belgium.
Oct. 6-10	2nd International Congress on Project Planning by Network Analysis	Amsterdam, Netherlands	Holland Organizing Centre, 16, Lange Voorhout, The Hague, Netherlands.
Oct. 21-24	International Conference on Quality Control	Tokyo, Japan	Secretary General, ICQC '69-Tokyo; c/o Union of Japanese Scientists and Engineers; 5-10-11, Sendagaya, Shibuyaku, Japan
Nov. 12-14	Probabilistic Concepts and Methods in Engineering	Lafayette, Indiana	A.D.M. Lewis, Purdue University, Lafayette, Indiana 47907.
Nov. 16-18	Operational Research Society Annual Conference	Eastbourne, England	Operational Research Society, Ltd. 62/64 Cannon Street, London E. C. 4, England.

ORSA VISITING LECTURESHIP PROGRAM

ORSA is continuing its Visiting Lectureship Program for the 1968-69 academic year with sponsorship from the National Science Foundation, and it is planned to continue the program in the 1969-70 academic year. The program has the following aims: to stimulate existing operations research courses and programs in universities and colleges which do not

at present offer degrees in operations research; to aid and motivate the starting of new operations research courses and curricula; to motivate able students toward careers in operations research; to provide education and information and advice to students, student counselors and faculty members on the availability of advanced training in operations research.

Lecturers will not only present formal lectures, but will be available to discuss teaching problems and curricula matters with members of the staff, and to advise students on future opportunities in study and employment.

Anyone interested in further information should write:

Visiting Lectureship Series in Operations Research
c/o Professor J. R. Borsting
Naval Postgraduate School
Monterey, California 93940

EDUCATION NEWS

The Education Committee will regularly publish information concerning degree programs in Operations Research. News of new programs or significant changes in existing programs should be sent to Prof. J. R. Borsting, Chairman, ORSA Education Committee, Naval Postgraduate School, Monterey, California 93940.

Yale University

New Haven, Connecticut 06520

The Management Science/Operations Research program at Yale University has developed within the context of the Department of Administrative Sciences. It focuses upon those problems of administration to which the concepts and methods of economics, applied mathematics, probability theory, engineering, and statistics are particularly relevant.

An undergraduate in the Department of Administrative Sciences may elect an intensive major in Management Science/Operations Research. The purpose of the major is to provide opportunity for fundamental study of complex systems. An undergraduate interested in Management Science/Operations Research alternatively may elect a Special Major in Administrative Sciences, Mathematics, and Statistics. This jointly sponsored program provides in-depth education in applied mathematics. The Department offers two advanced degree programs with essentially different objectives. One program leads to the degree of Doctor of Philosophy and the other to the degree of Master of Arts.

The Department of Administrative Sciences also offers undergraduate, doctoral, and master's programs in Organizational Behavior as well as specially designed programs that combine MS/OR and OB.

Inquiries: Graduate School, Yale University, Office of Admissions, Box 150A, Yale Station, New Haven, Connecticut 06520. An applicant should specify clearly whether he seeks the Ph.D. or M.A.

DEGREES OFFERED

B.S. in Administrative Sciences

B.A. in Administrative Sciences, Mathematics, and Statistics

M.A. in Management Science/Operations Research

Ph.D. in Management Science/Operations Research

*FACULTY**Primary Operations Research*

E. H. Bowman
G. H. Bradley
E. V. Denardo
R. B. Fetter

N. H. Hakansson
T. T. Holme
M. Shubik
M. J. Sobel

H. M. Wagner
W. Whitt
G. Wolf

*Associated with Operations Research**ECONOMICS*

D. Cass
A. K. Klevorick
T. J. Koopmans

R. R. Nelson
M. L. Nerlove
H. E. Scarf

J. E. Stiglitz
J. Tobin
M. Weitzman

ENGINEERING AND APPLIED SCIENCE

G. Mon
K. S. Narendra

T. Onat
P. M. Schultheiss

F. Tuteur

FORESTRY

G. Schreuder

MATHEMATICS

S. Kakutani

B. Randol

POLITICAL SCIENCE

G. Kramer

C. E. Lindblom

PSYCHOLOGY

R. Abelson
J. Brelsford

W. Garner
L. Huesmann

F. Sheffield
D. Taylor

STATISTICS

F. J. Anscombe
P. I. Feder

J. B. Kadane
B. H. Margolin

L. J. Savage

*COURSE OFFERINGS**Primary Operations Research*

108, Mathematics for Behavioral Analysis
115a, Economic Measurement
120b, Introduction to Operations Research
121, Probability and Statistics
124a, Industrial Statistics and Quality Control

126b, Linear Programming
 150a, Microeconomic Analysis
 150b, Macroeconomic Analysis
 160b, Statistical Methods
 166b, Corporate Finance
 170a, Financial Analysis
 180a, Experimental Gaming
 181b, Simulation and Artificial Intelligence
 201b, Strategy and Planning
 207, Capital Budgeting and Portfolio Selection
 208, Research in Business and Industrial Operations
 210a, Stochastic Models of Behavior
 217b, Flows in Networks
 218a, Special Topics in Flows in Networks
 219a, Operations Research
 220b, Seminar in Operations Research
 221a, Non-linear Programming
 222b, Special Topics in Non-linear Programming
 227a, Dynamic Programming
 228a,b, Special Topics in Dynamic Programming
 229a,b, Stochastic Decision Models
 231b, Integer Programming and Combinatorial Analysis
 232b, Special Topics in Queueing Theory
 238a, Project and Operations Economy

Associated with Operations Research

There are numerous associated courses with operations research content given in Economics, Engineering and Applied Science, Forestry, Mathematics, Political Science, Psychology, and Statistics.

RECENT AREAS OF RESEARCH

Adaptive economic decision models

All-integer integer programming algorithms
 Business games
 Capital asset equilibrium models under uncertainty
 Dynamic Programming
 Equivalent integer programs
 Facilities simulations
 Inventory and production theory
 Normative accounting models
 Operations of queueing systems
 Optimization in graphs
 Participative budgeting under uncertainty
 Political decision-making
 Portfolio selection
 Problems of distance, convex sets, and mathematical programming
 Scheduling with time-shared computers
 Separable Markovian decision models
 Stochastic and deterministic models of small groups and interpersonal behavior
 Top-management control systems
 Water resources

ENROLLMENT AND GRADUATION STATISTICS

Graduate Enrollment In Residence	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69
Masters	—	20	17	27	17	26
Ph.D	4	10	18	25	26	28
Graduation						
Masters	12	13	9	24	11	
Ph.D.	—	—	1	1	6	

Note—These figures are for the entire Department of Administrative Sciences.

NEW CURRICULA

University of Miami

A new curriculum in Systems Analysis is being offered by the University of Miami School of Engineering. Administered by the Department of Industrial Engineering and Systems Analysis, it leads to the Bachelor of Science degree.

Objective of the new curriculum is to develop a total systems theory which would relate the design and development of physical sciences with the man-made and the natural systems of the world, developing in the student a realistic understanding of systems analysis and an ability to apply it to business and public problems.

The new curriculum consists roughly of one year of humanistic social sciences, one year of mathematics and physical sciences, one year of systems analysis and computer-related courses, and a year of elective courses composed of a minor as well as more general elective courses.

Joseph J. Moder is chairman of the Department.

University of Wisconsin

At the University of Wisconsin, the Operations Research and Administrative Science (ORAS) activities have been organized as a University-wide Graduate School committee, rather than as a department. The only official course offering of the ORAS Committee at this time is a minor for the PhD degree. The University of Wisconsin is quite flexible in its arrangements for offering degrees not yet officially approved. Thus it is possible to have a committee of five professors appointed for supervising either the MS or the PhD in fields like ORAS. The ORAS Committee is designed to provide such flexibility for students who have interdisciplinary interests.

The procedure for admission to this program is to apply to a particular department clearly authorized to award the MS or the PhD degrees. The departments which support ORAS are Agricultural Economics, Business, Computer Sciences, Economics, Industrial Engineering, Mathematics, Political Science, Sociology, Statistics, and Urban and Regional Planning. In most of these departments it is possible to study various aspects of Operations Research without resorting to an interdisciplinary committee.

Persons interested in the ORAS program should arrange with a professor within his department for the ORAS Committee to set up a special program.

Members of the Committee are Loukas Arvanitis (Forestry), George Box (Statistics), John Brandl (Economics), Charles Falkner (Industrial Engineering), Erwin Gaumnitz (Business), Herman Karreman (Business, Mathematics Research Center), O. L. Mangasarian (Computer Sciences, Mathematics Research Center), William Moy (Industrial Engineering), Gerald Nadler (Industrial Engineering), Peter Ney (Mathematics), Richard Perlman (Economics), Seymour Spilerman (Sociology), Howard Thompson (Business), Elwood Weber (School of Business Administration—Milwaukee Campus), Shien-Ming Wu (Mechanical Engineering).

The Chairman of the Committee is Charles H. Falkner.

Union College

Union College, Schenectady, N. Y., has established an Institute of Industrial Administration from what for the past seven years has been a graduate program without formal administrative structure. The institute has the status of an academic department.

Alfred L. Thimm, professor of economics and industrial administration, is director of the new institute. The formation of the institute does not change the industrial administration program at Union, which enables students to work towards the Master of Arts degree in either industrial administration or operations research.

At present, about 450 students are enrolled in this program; about half of them in Poughkeepsie. All but 25 students in the program attend classes part time. The programs in Poughkeepsie and Schenectady are identical.

Union's industrial administration program differs from most other graduate programs in the field, because it seeks mature students with good technical backgrounds, and does not award degrees to anyone who does not have at least a full year of industrial experience.

COURSE OFFERINGS 1969

The following is a list of short courses to be offered between June and November of this year which may be of interest to the Membership. The list is certainly not exhaustive, since it includes only courses called to the Editor's attention by participating schools. For detailed information on course content, instructors, and housing, contact the person indicated.

State University of New York at Buffalo

June 15-20	Creative Problem Solving Institute	\$175
------------	------------------------------------	-------

Cornell University

June 10-14	Structure of Programming Languages	\$200
June 18-20	Topics in Mathematical Programming and Optimization	\$150
June 23-27	Automatic Text and Picture Processing	\$200
June 23-27	Applications of Probability and Stochastic Processes	\$200

Georgia Institute of Technology

June 2-6	Management Dynamics and Effective Decision Making	\$150
June 16-27	Summer Institute in Urban Renewal	\$300
June 16-27	An Institute on Scientific Methods in City Planning	\$300
July 7-18	Summer Institute in Urban Planning	\$300
July 7-18	Urban Planning Institute	\$300
July 14-18	The Fourth Annual Institute in Management Applications of Mathematical Programming	\$175
July 14-25	Management Applications of Mathematical Programming	\$300
October 20-24	Managerial Economics	\$175
November 17-21	Urban Transportation Planning and Analysis	\$175

Massachusetts Institute of Technology

June 16-27	Engineering Systems Analysis	\$500
July 31-August 1	Models for Financial Management and Long Range Financial Planning	
August 4-22	Analysis and Simulation of Chemical Processes	\$750

The University of Michigan

June 9-13	Recent Developments in Industrial Human Performance	\$250
July 7-18	Probability and Random Processes for Engineers and Scientists	\$400
July 7-18	Human Factors Engineering	\$350
July 21-August 1	Topics in Military Operations Research	\$350
August 4-15	Foundations and Tools for Operations Research and Management Sciences	\$400
August 4-15	Recent Mathematical Advances in Operations Research and the Management Sciences	\$400

UCLA

June 23-July 3	Advances in Digital Computer System Design	\$375
July 7-18	Queueing Systems, Theory and Applications	\$375
July 14-18	Numerical Analysis and Computer Methods in Engineering Systems	\$275
July 14-25	Computer Systems Analysis Methodology	\$375
July 14-25	Adaptive, Learning and Pattern Recognition	\$375
August 4-8	Artificial Intelligence	\$275
August 11-15	Question Answering and Theorem Proving by Computer	\$275
August 18-29	Computer Applications with Linear/Nonlinear Programming Optimization Procedures	\$375

For further information contact:

Dr. Sidney J. Parnes
Division of Continuing Education
State University of New York at Buffalo
5428 Main Street
Buffalo, New York 14221

Center for Advanced Engineering Study
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Director of Continuing Education
College of Engineering
251 Carpenter Hall
Cornell University
Ithaca, New York 14850

Engineering Summer Conferences
The University of Michigan
Chrysler Center
Ann Arbor, Michigan 48105

Director,
Department of Continuing Education
Georgia Institute of Technology
Atlanta, Georgia 30332

Program Promotion
P.O. Box 24902
University Extension, UCLA
Los Angeles, California 90024

PERSONAL ITEMS

RICHARD E. BECKWITH became Professor of Quantitative Methods and Associate Dean, School of Business Administration, at Georgia State College, Atlanta, Georgia.

OLIVER BRYK has joined the Systems Research Division of Exotech Incorporated, Washington, D. C., as Consulting Scientist.

ABRAHAM CHARNES has assumed the duties of the first Jesse H. Jones Professor in the Graduate School of Business at the University of Texas, Austin, Texas, as well as University System Professor. In the latter role he will be associated both with the School of Business and the University's M.D. Anderson Hospital and Tumor Institute in Houston.

HOWARD EISNER has been promoted to Vice President and Director of the Engineering Analysis Division of Operations Research Incorporated (ORI), Silver Spring, Maryland.

WALTER H. GRIFEL has joined the Operations Research Group of RCA Management Information Systems at the David Sarnoff Research Center in Princeton, New Jersey.

FRED S. HOFFMAN, formerly Assistant Director of the U.S. Bureau of the Budget in the Executive Office of the President, has joined Laird Systems, Inc., Los Angeles, and New York City, as Vice President.

EDWARD P. LOANE has been promoted to Vice President, Daniel H. Wagner, Associates, Paoli, Pennsylvania.

JACK MOSHMAN, Vice President, Leasco Systems and Research Corporation, has been appointed Chairman of the Computer Sciences and Technology Advisory Panel of the National Bureau of Standards.

SANFORD T. ROSENTHAL has joined Applied Technology, a division of Itek Corporation, Palo Alto, California, as Senior Engineer.

MARVIN ROTHSTEIN has joined the Hartford National Bank and Trust Co., Hartford, Connecticut, as Director of Management Science.

ERIC SORENSON has joined Optimum Systems, Palo Alto, California, as a Senior Member of the technical staff.

ALLAN J. TRUELOVE has joined the staff of MATHEMATICA, Bethesda, Maryland, as a Consulting Mathematician.

ANDREW UNGAR has been promoted to Associate Technical Director of Matson Research Corporation.

EDWIN L. WOISARD, Vice President of Kettelle Associates, Inc., Paoli, Pennsylvania, has assumed the additional duties of manager of the Systems Analysis Division.

JAMES K. YARNOLD has joined the Atlantic Systems Center of URS Systems Corporation, Falls Church, Virginia.

WARREN RANDOLPH CHURCH, Professor Emeritus and former Chairman of the Department of Mathematics at the Naval Postgraduate School, passed away on February 8, 1969. Professor Church was instrumental in creating an M.S. program in Operations Research at the Naval Postgraduate School in the early 1950's. This M.S. program was one of the first graduate programs in Operations Research in the country. Professor Church was an early member of ORSA and encouraged recruitment of personnel to develop the operations research program at Monterey.

Perhaps his outstanding traits were his love for all things mathematical and his desire to understand them completely, and to lead others to understand and appreciate them. At any hour of day or evening, he could be found with colleagues and students grouped around a blackboard or table, analyzing some problem. His broad knowledge of mathematics and mathematical activities was a continuing source of amazement and inspiration to those who were fortunate enough to work with him. Perhaps his finest characteristic as a leader was the ability to see and to bring out the best in those who worked with him. His great personal integrity was balanced by patience, tact, and a strong sense of human dignity.

His interests were quite broad and beyond the usual things a mathematician would be interested in. For example, his publications included a reconstruction of the original text of part of the New Testament Book of John. Dr. Church also constructed some unique mathematical models which are masterpieces of craftsmanship.

INFORMATION ON ORSA MEMBERSHIP

Any person interested in Operations Research may become an *Associate Member* by submitting an application accompanied by appropriate dues. Students working for a degree in a recognized college at least half-time and enlisted personnel of the Armed Forces of the U.S.A. may apply for *Student Associate Membership*. Applicants for admission as full *Members* will initially be granted *Associate Membership* pending consideration of their election to full *Membership*, unless otherwise requested. All members receive OPERATIONS RESEARCH, the Journal of the Society, and, in addition, INTERNATIONAL ABSTRACTS IN OPERATIONS RESEARCH. Subscriptions to TRANSPORTATION SCIENCE are available at the reduced rate of \$6.00 per volume.

For election to full *Membership* an applicant must supply pertinent information for the Membership Committee and receive the favorable votes of the majority of that Committee prior to a final vote by the Council, which is normally taken only twice a year. An applicant for election as full *Member* and his references may receive requests for further information from the Chairman of the Membership Committee. Normally two full *Members* of ORSA are required as references of eligibility.

The following criteria of eligibility are offered as a guide to potential *Members*:

- (a) Experience of at least two years demonstrating ability to do effective and original professional work in operations research or
- (b) Experience of at least two years in a field closely related to operations research, provided there is evidence of interest in operations research problems, and evidence of ability to do effective and original professional work on these problems, or
- (c) Management responsibility for activities embracing operations research; in such case, the individual should hold such position by virtue of technical qualification, or
- (d) Academic appointment, with responsibility for operations research or related courses, for at least two years, or
- (e) Substantive open publications on operations research.

Annual dues are \$15.00 for *Members* and *Associate Members*, \$8.50 for *Student Associate Members* and \$13.50 for *Members* and *Associate Members* residing outside the U.S. and Canada. Half year dues (after July 1) are 50 % of the annual dues but entitle the member to only the publications for the last half of the year.

Requests for membership information and applications as well as subscriptions to Society publications should be addressed to:

Operations Research Society of America
428 East Preston Street Baltimore, Maryland 21202



national meeting

WASHINGTON, D.C.

APRIL 20-22, 1970

BULLETIN



OF THE OPERATIONS RESEARCH SOCIETY OF AMERICA

OPERATIONS-RESEARCH □ Volume 18 Supplement 1 Spring 1970

THE BULLETIN

is published twice a year
with occasional special issues

News and Announcements for the BULLETIN of
the OPERATIONS RESEARCH SOCIETY OF AMERICA
may be sent to the Editor:

PAUL GRAY
Stanford Research Institute,
Menlo Park, California 94025

Please Note

Copies of papers abstracted in the BULLETIN are *not* available from the *Editor* of the BULLETIN, nor from Officers of the Society. Such requests should be directed to the authors at the addresses shown in the Program; they cannot be forwarded or acknowledged by the Editor. *News and Announcements* of new products, commercial courses, and personal items regarding non-members are not usually printed in the BULLETIN, nor are photographs. Orders for back issues of the BULLETIN and OPERATIONS RESEARCH, as well as membership applications, should be directed to the ORSA Business Manager, 428 East Preston Street, Baltimore, Maryland 21202.

Copyright © 1970 by the Operations Research Society of America
Published by the Operations Research Society of America at 428 East
Preston Street, Baltimore, Maryland 21202.
Printed in U.S.A.

Operations Research Society of America

1969-1970

OFFICERS OF THE SOCIETY

President: THOMAS E. CAYWOOD, Caywood-Schiller Associates, 401 N. Michigan Ave., Chicago, IL 60611

Vice President: W. EDWARD CUSHEN, National Bureau of Standards, U. S. Dept. of Commerce, Washington, DC 20234

Secretary: ROBERT E. MACHOL, School of Business, Northwestern Univ., 339 East Chicago Ave., Chicago, IL 60611

Treasurer: KENNETH W. YARNOLD, System Development Corp., 2500 Colorado Ave., Santa Monica, CA 90406

COUNCIL OF THE SOCIETY

1967-70 Past President: JOHN F. MAGEE, Arthur D. Little, Inc., 35 Acorn Park, Cambridge, MA 02140

1968-71 Past President: JOHN E. WALSH, Statistics Dept., Southern Methodist Univ., Dallas, TX 75222

1969-72 Past President: JOSEPH H. ENGEL, Communications Satellite Corp., 950 L'Enfant Plaza South, SW, Washington, DC 20024

1967-70

ERNEST KOENIGSBERG, Matson Research Corp., 215 Market St., San Francisco, CA 94105

GEORGES BRIGHAM, American Can Co., 100 Park Ave., New York, NY 10017

1968-71

CHARLES D. FLAGLE, The Johns Hopkins Univ., School of Hygiene and Public Health, Baltimore, MD 21205

DAVID S. STOLLER, McDonnell Douglas Astronautics Co., Huntington Beach, CA 92647

1969-72

JACK R. BORSTING, Dept. of Operations Analysis, U.S. Naval Postgraduate School, Monterey, CA 93940

CLAYTON J. THOMAS, 413 River Bend Rd., Great Falls, VA 22066*

BUSINESS OFFICE

Requests for membership information and applications as well as subscriptions and orders for back issues of *Society* publications should be addressed to:

Operations Research Society of America
428 East Preston Street
Baltimore, Maryland 21202
(301) 727-2870

ADVERTISING MANAGER

CHARLES P. CHADSEY, Research Analysis Corp., McLean, Va. 22101
(703) 893-5121

EDITORS OF ORSA PUBLICATIONS

OPERATIONS RESEARCH, The Journal of the Operations Research Society of America. HUGH J. MISER, *Editor*, Post Office Box 520, Windsor, CT 06095

BULLETIN of the Operations Research Society of America
PAUL GRAY, *Editor*, Stanford Research Inst., Menlo Park, CA 94025

TRANSPORTATION SCIENCE

ROBERT HERMAN, *Editor*, GM Research Laboratories, 12 Mile and Mound Roads, Warren, MI 48090

INTERNATIONAL ABSTRACTS IN OPERATIONS RESEARCH

HUGH E. BRADLEY, *Editor*, The Upjohn Co., Kalamazoo, MI 49001

PUBLICATIONS IN OPERATIONS RESEARCH

DAVID B. HERTZ, *Editor*, McKinsey & Company, Inc., 245 Park Ave., New York, N.Y. 10017

COMMITTEES AND REPRESENTATIVES

Membership Committee

EZRA KRENDEL, *Chairman*, Management Science Center, University of Pennsylvania, Philadelphia, PA 19104

Education Committee

JACK R. BORSTING, *Chairman*, Dept. of Operations Analysis, U.S. Naval Postgraduate School, Monterey, CA 93940

Publications Committee

ROBERT OLIVER, *Chairman*, Office of Institutional Research, Bldg. T-8, Room 210, Univ. of California, Berkeley, CA 94720

Nominating Committee

GEORGE E. NICHOLSON, JR., *Chairman*, Dept. of Statistics, Univ. of North Carolina, Chapel Hill, NC 27515

Lanchester Prize Committee

JOHN MAGEE, *Chairman*, Arthur D. Little, Inc., 35 Acorn Park, Cambridge, MA 02140

Sections Committee,

WALTER HELLY, *Chairman*, 91 Central Park West, New York, NY 10023

Meetings Committee

ARMAND B. WEISS, *Chairman*, Logistics Management Institute, 4701 Sangamore Rd., Washington, D. C. 20016

Representative to IFORS

JOSEPH H. ENGEL, Communications Satellite Corp., 950 L'Enfant Plaza South, SW, Washington, DC 20024

Representative to the NRC

HUGH J. MISER, School of Engineering, Univ. of Massachusetts, Amherst, MA 01002

Representatives to the AAAS

WALTER L. DEEMER, Arms Control and Disarmament Agency, New State Dept. Bldg., Washington, DC 20451

ELLIS A. JOHNSON, 4819 Essex Ave., Chevy Chase, MD 20015

GEORGE W. MORGENTHAUER (*Alternate*), Martin Marietta Co., Box 179, Dept 1600, Denver, CO 80201

Representative to the Conference Board on Mathematical Sciences

ROBERT F. RINEHART, U.S. Naval Postgraduate School, Monterey, CA 93940

BULLETIN

OF THE

Operations Research Society of America

Supplement 1

OPERATIONS RESEARCH

Volume 18, 1970

Program of the Thirty-Seventh Meeting

REGISTRATION INFORMATION	B-2
COMMITTEE FOR THE MEETING	B-5
INDEX OF PARTICIPANTS	B-6
SESSION CHAIRMEN	B-9
SUMMARY OF EVENTS	B-10
PROGRAM/SESSION SCHEDULE	B-12
FLOOR PLANS	B-13
PROGRAM OF THE MEETING	B-14
ABSTRACTS OF THE PAPERS	B-35
Society Affairs	B-79
News and Announcements	B-84
ORSA Sections	B-94

37th NATIONAL MEETING Washington, D.C.

April 20-22, 1970

REGISTRATION INFORMATION

Registration

The Registration Desk will be located in the Concourse Level of The Washington Hilton Hotel and will accommodate preregistered and unregistered delegates at the following times:

Sunday, April 19	6:00 p.m. — 10:00 p.m.
Monday, April 20	8:00 a.m. — 5:00 p.m.
Tuesday, April 21	8:00 a.m. — 5:00 p.m.
Wednesday, April 22	8:00 a.m. — 2:00 p.m.

Fees for registration and functions are as follows:

ORSA Member Registration*	\$20.00
Non-member Registration	25.00
Full-time Student Registration	3.00
Luncheon (Monday)	5.75
Luncheon (Tuesday)	5.75

Preregistration

Preregistration with or without prepayment for the meeting and other events is strongly encouraged. A preregistration form is enclosed. Please make check or money order (no cash) payable to 37th ORSA. Send to: Eugene Visco, GEOMET, 326 E. Montgomery Avenue, Rockville, Maryland 20850. In returning the registration form, members are requested to indicate which special events they plan to attend. This will enable the Committee to set minimum guarantees with the hotel.

Accommodations

The Washington Hilton, Connecticut Avenue at Columbia Road, N.W., Washington, D.C: 20009, 202-483-3000, is the official headquarters and meeting hotel. A block of 440 rooms has been reserved for attendees. Daily rates are indicated on the enclosed hotel reservation form. To reserve a room, mail the enclosed form directly to The Washington Hilton.

THE PROGRAM

As befits a meeting in the nation's Capital, the theme of this meeting is "Operations Research on Government Problems." The program reflects this theme in that the majority of the sessions are directed towards specific problem areas encountered within federal and

*A non-member submitting an application for membership when registering may register at the member rate; membership desk will be located in the registration area.

local government activities. In particular we want to cite the series of three sessions on OR and The City, the three sessions sponsored by the Washington Operations Research Council, and the sessions sponsored by the ORSA Sections.

Two special plenary sessions will be held on Monday, April 20 and Wednesday, April 22 at 11:30 a.m. in the International Ballroom Center. These sessions will feature an invited speaker from the realm of government; specific speakers will be announced at a later date. All members are urged to attend these plenary sessions.

The majority of the sessions consists of invited papers or panels, with contributed papers being given in a seminar style. The seminars will be held in the Jefferson Room, with each author having an hour and fifteen minutes to discuss his paper with all comers. Each author will be provided with table, chairs, blackboard, other visual aids as needed, and a sign announcing his paper. The physical arrangement of these seminars will permit simultaneous presentation of a number of papers without interference. The audience is invited to visit a number of seminars. These sessions (powwows) are intended to provide an opportunity for attendees with common areas of interest to meet and discuss their work on an informal basis. Authors should bring or send ahead to the hotel (in their name) copies of their papers, presentation charts, or other visual aids.

Abbreviations are used to identify the technical sessions and papers in these sessions. The first letter is either R or S. R denotes the regular sessions while S denotes the seminar sessions. The second letter denotes the day of the week; M, T, or W, while the third, either an A or P, indicates morning or afternoon respectively. The first numeral gives the session number and the second gives the position of the paper in the session.

SPECIAL FUNCTIONS

ORSA-sponsored luncheons will be held on Monday, April 20 at 12:30 p.m. and Tuesday, April 21 at 12:00 noon in the International Ballroom Center. On Monday, president Thomas E. Caywood will deliver the retiring presidential address. On Tuesday, a special invited speaker (to be announced) will deliver the keynote address. As space is limited, members are urged to register early for these functions. Monday's luncheon menu includes: Turtle Soup, Roast Sliced Breast of Turkey and Ham on Bed of Broccoli Mornay, Rissoles Potatoes, Tossed Green Salad with Castellana Dressing, Napoleon's Delight, Coffee, Tea, or Milk. Tuesday's luncheon menu includes Grapefruit Segments au Triple Sec, Broiled Chopped Steak with Mushroom Sauce, Broiled Tomato Parmesan, Pommes Croquettes, Ice Cream Log with Strawberry Sauce, Coffee, Tea or Milk.

A no host, get-acquainted cocktail party will be held for early arrivals on Sunday, April 19 from 6:00 p.m. to 10:00 p.m. in the Georgetown Room next to the registration area.

The annual ORSA mixer cocktail party will be held on Tuesday, April 21 from 6:00 p.m. to 8:00 p.m. in the Terrace Level reception area.

PASSOVER SEDER

As the first night of Passover is Monday, April 20, we have arranged with The Washington Hilton to hold a Passover Seder for ORSA members and guests who wish to attend. It will start at 7:00 p.m. in the Lincoln Room. A Passover service will be held and a typical seder meal will be served. The cost will be \$10.25 for adults and \$6.50 for children under 12 years. The price includes wine, gratuity and tax. As the minimum guarantee must be given before registration occurs at the hotel, we ask all who plan to attend to pay in advance and indicate attendance on the enclosed registration card.

LADIES' PROGRAM

Wives are cordially invited to attend all technical sessions, especially the plenary sessions, as guests of ORSA. The Chevy Chase Room (Monday and Tuesday) and the Farragut Room (Wednesday) have been set aside as Hospitality Rooms for the ladies. An informative, but relaxing ladies' program has been scheduled as follows:

Monday April 20

A get-acquainted coffee reception will be held on Monday morning from 9:30 a.m. to 10:00 a.m. in the Crystal Room West. This will be followed by an informal lecture on

"What Your Husband is Really Doing with His Models" given by Dr. Harold (Hal) O. Davidson, Senior Director of the Arthur Young and Company, Bethesda, Maryland. This lecture is *not* open to husbands.

A half-day bus and visit tour of Embassy Row and The National Cathedral is planned following the Monday ORSA luncheon. The cost of this tour is \$3.00.

Tuesday April 21

This full-day tour of Washington and surrounding points includes stops at The Lincoln Memorial, Arlington Cemetery, Marine Memorial, Alexandria and Mt. Vernon. Lunch will be at the Lazy Susan Inn, Woodbridge Virginia. The cost of this tour is \$10.00, including lunch and admission to Mt. Vernon.

Wednesday April 22

No planned activity. A walking-shopping tour along Connecticut Avenue is suggested; or a visit to The National Gallery of Art; or a visit to the nearby Phillips Gallery to view Renoir's famous "Luncheon of The Boating Party."

As an aid in planning, those wives who plan to go on the tours and attend the Monday luncheon are requested to check the appropriate boxes on the enclosed registration card. Tickets for all functions are limited and can be purchased in advance or at the registration desk.

ANNUAL ORSA BUSINESS MEETING

The Annual ORSA Business Meeting will be held in the Lincoln Room West on Tuesday, April 21 at 5:00 p.m.

FIRST SPACE SCIENCES SECTION AWARD

This annual award for outstanding contributions to space sciences will be presented for the first time to Dr. Amrom H. Katz of the Rand Corporation. The award will be made at the ORSA luncheon on Monday, April 20.

TECHNICAL SECTIONS

The various technical sections of the Society will hold business meetings during this meeting. Notices as to times and places of these meetings will be posted on the bulletin board. A business meeting of the Transportation Science Section is scheduled for Monday, April 20 at 5:00 p.m. in the Edison Room.

COPIES OF PAPERS

Requests for copies of papers and for information about presentations must be sent directly to the authors and not to the Committee for the meeting, the session chairmen, or the Editor of *The Bulletin*.

BOOK EXHIBIT

A book display of general interest to ORSA members will be available in the hallway in front of the Jefferson Room. The display will be prepared by Conference Book Service, Inc., a representative of over two hundred publishing houses.

MESSAGE CENTER

A telephone message center will be located in the Washington Hilton adjacent to the Registration Desk.

PROGRAM COVER

The program cover reflects the theme "CR on Government Problems" and was executed by Graphic Communications Systems, Inc., Bethesda, Maryland.

WEATHER AND DRESS IN WASHINGTON IN APRIL

We will have weather and there is a non-zero probability that it will rain and/or be beautiful. Your Committee is planning on the latter. April is a transition period for Washington weather and attendees cannot go wrong by bringing their winter and/or summer attire.

COMMITTEE FOR THE WASHINGTON MEETING

ORSA General Chairman:

HOWARD BERGER
Xerox Corporation
Xerox Square
Rochester, New York 14603

Program Chairman:

SAUL I. GASS
World Systems Laboratories, Inc.
7979 Old Georgetown Road
Bethesda, Maryland 20014

Arrangements Chairman:

GEORGE K. CHACKO
TRW Systems
1735 I Street, N.W.
Washington, D.C. 20006

Finance and Registration Chairman:

EUGENE VISCO
GEOMET, Inc.
326 E. Montgomery Avenue
Rockville, Maryland 20850

Seminar Session Chairman:

MRS. JOANN LANGSTON
GEOMET, Inc.
326 E. Montgomery Avenue
Rockville, Maryland 20850

Bulletin and Publicity Chairman:

MARTIN CHASE
Chase, Rosen and Wallace, Inc.
901 N. Washington St.
Alexandria, Virginia 22314

ABRAMS, E. D., S-TA1.7
 AGNEW, R. A., S-TA2.1
 ALTMAN, E. I., S-WP1.10
 ARCHIBALD, R. W., R-TP4.3
 ARORA, S. R., S-WA1.1
 ASHOUR, S., S-WA1.2
 AU, T., R-WP3.2
 AZOLA, M. P., S-MA2.1

BAILEY, D., R-MP3.2
 BAISUCK, A., R-MP3.4
 BAKER, N. R., S-MP1.7
 BAKER, R. L., R-WP3.8
 BARNES, C. F., R-WA3.4
 BARTLETT, J., S-TP1.1
 BASILE, J., R-MA3.1
 BEATON, A. E., R-WP2.2
 BECKMAN, M. J., R-TP3.6
 BELLAR, F. J. Jr., S-TP1.2
 BELLMORE, M., R-TP3.5
 BERKMAN, H. G., S-MP1.1
 BHAT, U. N., S-TA1.9
 BHAUMIK, G., S-MA1.6
 BISBEE, E. F., R-MA3.3
 BLANKEHSHIP, L. V., R-TP4.2
 BODO, J., S-TP1.3
 BONDER, S., R-WA2.1, R-WA2.3
 BORSTING, J., R-WA2.3
 BOTTOMS, A. M., R-MA1.2
 BOWES, D. J. JR., R-WP4.1
 BOWMAN, V. J., R-TP2.3
 BRIGGS, W., S-MP2.3
 BROWN, D. G., S-WP1.9
 BROWN, E. E., S-TP1.4
 BRUGGEMAN, J. M., R-TP3.8
 BRUNO, J., R-MP3.1
 BURKHARDT, J., R-MP2.2
 BURNS, T. J., R-TA3.3

CAROL, A., S-MP2.1, S-WP1.1
 CASE, H. W., R-TA5.6
 CASSIDY, W. D., S-TA2.2
 CHARTRAND, R. L., R-TA2.3
 CHAUBEY, S. D., R-MP5.2
 CHEN, D. S., S-WA2.1
 CHEN, H., S-TA2.3
 CHIDAMBARAM, T. S., S-WP1.2
 CHORBA, R., R-WP3.7
 CHOU, W., R-MP5.3
 CHRISTENSEN, D. W., R-WP4.3
 CHUANG, Y. C., R-MP3.3
 CICIRELLI, V. G., R-MA2.2
 CLARK, J. S., S-WA1.3
 CORAZZINI, A. J., R-WP2.4
 CRABILL, T. B., S-WA1.4

CRAIG, D. W., R-MA1
 CRANE, J., R-WA3.3
 CULHAN, H., R-MP4.1
 CZEWINSKI, T., R-TA4.3

DAVIS, R. M., R-TA2.2
 DEAN, B. V., R-MP4.4
 DEBANNE, J. G., S-WA1.11
 DEMETSKY, M. J., R-MA3.4
 de NEUFVILLE, R., R-MP2.3
 deWALD, C. G., S-TA2.3, S-TA2.4, S-TA2.8
 DICKEY, J. W., S-MA2.1
 DUBERG, J., S-TA1.1
 DUGAN, D. J., R-WP2.3

EBY, C., R-MP2.2
 ELTON, E. J., S-MP2.2
 EMLET, H. E. JR., R-WP3.1
 EPLAN, L., R-WA1
 ERCAN, S. S., R-MP2.5
 ERLICH, I., R-MA1.1
 EVANS, J. W., R-MA2.1

FABRYCKY, W. J., S-MA1.1
 FAUCETT, W. M., R-WP4.6
 FLAX, M. J., S-MP1.4
 FLORIAN, M., S-TA2.5
 FLOYD, P., R-WA1
 FRANK, H., R-MP5.5
 FRISCH, I. T., R-MP5.2
 FUNG, V., S-MP2.3

GARDNER, S., R-TA1.4
 GAVER, D. P., R-TP2.4
 GERSHENSON, S., R-TA1.4
 GILBERT, R. D., R-WP4.6
 GILSINN, J. F., S-TA2.6
 GODFREY, M. B., R-TP3.3
 GOLD, M., R-TA2.4
 GOLDMAN, A. J., S-WA2.2
 GOLDSTEIN, M., R-MP5.4
 GRACE, J. C., S-MP2.4
 GRAY, A., S-WA2.3
 GRECCO, W., S-MP1.7
 GREENBERG, R. I., S-WP1.3
 GRUBER, M. J., S-MP2.2
 GUHA, D. K., S-WA2.4
 GUPTA, J. N. D., S-WA1.5
 GUSTAFSON, D., R-TA1.3

HAEHLING VON LANZENAUER, C.,
 S-MP2.5

HALDER, A. K., S-MP2.6
 HALL, W. G., S-WA1.6
 HALL, W. K., R-TA5.2
 HAMELMAN, P., R-MP3.2

HAMILTON, L., R-WA4.6
HAMSON, R. L., R-MP2.4, R-TA3.4
HARDER, M., R-WA4.3
HARDING, W., R-WP3.8
HARE, R. R., S-MA2.11
HARRIS, C. J., S-MP1.2
HAUSSMAN, D., R-TP4.4
HAYWARD, P., S-MP2.7
HEATHINGTON, K. W., S-TA1.3
HEILBRON, R. D., R-TA5.4
HELLER, N. B., S-MA2.2
HELLY, W., R-TP3.2
HIREMATH, S. R., S-WA1.2
HOEL, L. A., R-MA3.4
HOFFMAN, R. B., R-TP4.1
HOLZMAN, A. G., S-MA1.9, S-WP1.7
HOPKINS, D. S. P., R-TA3.2
HORN, W. A., S-TA2.7
HULLANDER, E., S-WP1.4
HUNTER, D. E., S-MP1.3

JAQUETTE, D. L., R-WP3.3
JENNINGS, J. B., R-WP3.6
JESSIMAN, W. A., R-MA3.1
JOEL, L. S., S-MP2.8
JOKSCH, H. C., R-TA5.3
JONES, C. E., R-MP4.1
JONES, M. V., S-MP1.4
JONES, S., S-MA1.11
JUDY, R. W., R-TA3.4

KABAK, I. W., S-TA1.10
KALIN, S., S-TA1.4
KALRO, A., S-WA1.1
KAPUR, K. C., R-TP3.1
KATZ, L., S-MA1.10
KEENEY, R. L., S-MA2.3
KHAN, M. U., S-WA1.7
KINGSTON, P. L., S-MA1.2
KLEIN, M., R-MP4.2
KLEINROCK, L., R-MP5.1
KLEITMAN, D. J., R-MP5.5
KOENIGSBERG, E., R-WA5
KU, R., R-MA3.5
KUMBARACI, T. E., S-MP2.9
KÜNZI, H. P., R-TP3.6
KYLE, T., S-TP1.5

LAGO, A. M., R-WA3.1, S-TA1.5
LARSON, R. C., R-WP1.3
LEININGER, W. J., R-TA5.4, S-MP1.5
LEVY, E., S-WP1.9
LEVY, J., S-TA1.6
LICHSTEIN, H. A., R-TA2.1
LIEBMAN, J. C., R-TP3.5, S-MA2.4
LIECHENSTEIN, M., R-MA1.3
LIMAYE, D. R., S-WP1.9

ENVILL, W. K., R-WA2.2, R-WA2.3
LITTLE, J. D. C., R-WA2.3
LOVE, G. G., R-TA1.1

McCALLUM, R., S-TP1.7
McMICHAEL, R. W., R-WP4.6
McNICHOLS, G. R., R-WP4.4
McQUIE, R., R-WP4.2
McROBERTS, K. L., S-WA2.5
MANAHAN, D., S-TP1.6
MARKLAND, R. W., S-MA2.2
MARKS, D. H., R-TP3.5, S-MA2.4
MATHIAS, R. A., R-TA1.1
MAXFIELD, D. P., R-MA3.1
MAYESKE, G. W., R-WP2.1
MEIER, W. L., JR., S-MA2.9, S-WA2.3
MENSCH, G., S-WA2.6
MILLER, D. S., S-MA2.9
MILLER, J., R-WP3.7
MILLER, J. E., R-WP3.5
MINTZ, R., S-MP1.6
MISER, H. J., R-TA5.1, R-WA5
MISNER, G. E., R-TP4.2
MOORE, S. C., R-WP4.6
MOSHMAN, J., R-WA5
MOSS, J. H., R-WP3.4
MUKHERJEE, S. K., S-MA2.5
MULLENS, L., R-WP3.8
MURPHY, E. F., R-TP1

NADDOR, E., R-TP2.1
NANCE, R. E., R-TP2.2
NELSON, F. M., S-TP1.2
NEMHAUSER, G. L., S-WA2.7
NEWTON, R. M., S-MA1.3

OBEL-OMIA, C., R-TA4.6
O'CONNOR, A. D., S-TA2.8
O'DAY, J., R-TA5.2
O'HAGAN, J. T., R-TP4.4
OREN, R. A., S-WP1.9

PARKER, E., R-WA3.3
PARKER, J., R-WA1
PARTI, E. W., R-WP3.2
PATTEN, C. W., S-TP1.8
PEARL, M. H., S-TA1.6
PERRINE, M. W., R-TA5.5
PINSKY, P. D., S-MA1.4
PRABHAKAR, T., S-WA1.8
PRESSMAN, I., R-TP3.2, S-WP1.1

QUINTANA, B., R-WA3.2

RAO, A., S-WA1.9
RATH, G. J., R-TA3.1
RAUD, M., R-TA4.2
RAVINDRAN, A., S-WA2.8

ROBERT, P., S-TA2.5
 ROBINSON, R., R-TP1
 ROEPCKE, L. A., R-MP4.4
 ROSENBLUM, S., R-TP4.4
 ROSENTHAL, S. R., R-WP1.1
 ROSS, D., R-TA4.5
 ROSS, J. A., R-TP1
 ROSSIN-ARTHIAT, M., S-TA2.5
 ROTHFRAB, B., R-MP5.4, R-MP5.5
 RUEFLI, T. W., S-MA1.5
 RUSIN, M., S-WA2.9

SALISBURY, P., R-WA4.5
 SALMON, R. J., R-TA1.4
 SANDERS, J. L., R-WP3.7
 SANDERSON, R. D., S-TA2.9
 SAUNDERS, P. B., R-MA3.2
 SAVAS, E. S., R-WA2.3, R-WP1.4
 SCARBOROUGH, J. C., S-WP1.5
 SCHAAKE, J. C., S-MA2.6
 SCHAFFER, T., S-MA2.7
 SCHIMPELER, C. C., S-MP1.7
 SCHOEMAN, M. E. F., S-MA1.6
 SCHOTTA, C., R-MP3.2
 SCHWARTZ, R. A., S-WP1.10
 SCOTT, M., S-TA1.2
 SEN, S. K., S-MP2.10
 SHAIN, R. B., S-MP1.8
 SHANNON, R. E., S-MA2.8
 SHIH, C. S., S-MA2.9
 SLEE, V. N., R-MA2.4
 SMALLWOOD, R. D., R-TA1.2
 SMITH, B. G., R-MP2.1, S-MA2.10
 SOUDER, W. E., R-MP4.3
 STEIGLITZ, K., R-MP5.5
 STEVENSON, K. A., R-MA1.4
 STROPE, D., S-MA1.7, S-MP1.9
 SWEETZ, E. E., S-MP2.11
 SWERSEY, A. J., R-WP1.2
 SWID, R., R-TA1.4

TABAK, D., S-WA2.10

TAFT, M. D., S-MA1.8, S-MP1.10
 TAYLOR, J. G., S-TP1.9
 TENNANT, J. C., R-TP3.7
 TERRIS, D., R-WP4.3, S-TP1.10
 THOMAS, R. W. L., SWA1.10, SWA2.11
 THOMAS, W. H., S-MA1.3
 THOMPSON, G. L., R-TP2.4
 TOWLES, W. T., R-MP2.1
 TRAMPOSCH, H., S-WP1.6
 TREBBI, G., R-TA1.1
 TURKSEN, I. B., S-MA1.9, S-MA1.10

VANECKO, J. J., R-MA2.3
 VAN TIJN, D. E., S-TA1.7

WALLACE, W. A., R-MP3.4
 WALTER, J. R., S-MA1.11
 WARD, D. E., R-MA3.1
 WARD, J. R., R-MP2.1
 WASS DE CZEGE, M., R-TA4.1, R-TA4.4,
 R-WA4.1, R-WA4.4
 WEISMAN, J., S-WP1.7
 WELLS, R. C. R-TP1
 WEMPLE, A. B., S-MA2.11
 WESTON, F. C., Jr., R-WP4.5
 WETMORE, N., R-WA4.2
 WHEELER, A. C., S-WP1.8
 WHITON, J. C., S-TP1.11
 WIDHELM, W. B., S-WA2.7
 WILKINS, L., R-TP4.2
 WILLIAMS, J. B., S-TA1.8
 WILSON, R., S-MA1.11
 WITZGALL, C., S-TA2.6
 WORRALL, R. D., R-TP3.8, S-MP1.11
 WYSKIDA, R. M., S-MA2.8

YAGED, B. Jr., S-TA2.10
 YAGODA, H., R-TP3.2
 YEN, J. Y., S-TA2.11

ZIONTS, S., S-WA2.1

SESSION CHAIRMEN

- R-MA1** Alfred Blumstein, School of Urban and Public Affairs, Carnegie-Mellon University, Pittsburgh, Pa.
- R-MA2** James G. Abert, Deputy Assistant Secretary for Evaluation and Monitoring, HEW, Washington, D.C. 20201
- R-MA3** E. Farnsworth Bisbee, 308 Town Bldg., University of Pennsylvania, Philadelphia, Penna., 19104
- R-MA4** Paul R. Swan, NASA Mission Analysis Division, Mail Stop 202.9, Moffett Field, Calif., 94035
- S-MA1** Theodore J. Wang, The Institute for Creative Studies, 4700 Essex Avenue, Chevy Chase, Md.
- S-MA2** John R. Ward, GEOMET, Inc., 326 E. Montgomery Avenue, Rockville, Maryland 20850
- R-MP1** E. W. Paxson, Rand Corporation, 1700 Main Street, Santa Monica, California, 90406
- R-MP2** E. S. Quade, Rand Corporation, 1700 Main Street, Santa Monica, California, 90406
- R-MP3** Gustave J. Rath, Design and Development Center, Northwestern University, Evanston, Illinois
- R-MP4** Burton V. Dean, School of Management, Case Western Reserve University, Cleveland, Ohio 44106
- R-MP5** Howard Frank, Network Analysis Corporation, Beechwood, Old Tappan Road, Glen Cove, N.Y. 11542
- S-MP1** Gordon B. Page, Research Associates, Inc., 8525 Colesville Road, Silver Spring, Maryland
- S-MP2** Harry Weintrob, Leasco Systems and Research, 4833 Rugby Ave., Bethesda, Maryland 20014
- R-TA1** Charles D. Flagle, School of Hygiene and Public Health, The Johns Hopkins University, 615 N. Wolfe Street, Baltimore, Maryland 21205
- R-TA2** Hugh V. O'Neill, GE/TEMPO, 777 14th Street, N.W., Washington D.C. 20005
- R-TA3** William Dorfman, Room 1187A, Office of Education, 400 Maryland Ave., S.W. Washington, D.C.
- R-TA4** Miklos Wass de Czege, Department of Public Instruction Madison, Wisconsin, 53702
- R-TA5** Paul Gray, Stanford Research Institute, Menlo Park, Calif, 94025
- S-TA1** William Bihlon, Military Traffic Management and Terminal Services, Baileys Crossroads, Va.
- S-TA2** Ric Blacksten, Mathematica, 4905 Del Ray Avenue, Bethesda, Md. 20014
- R-TP1** Evelyn F. Murphy, OSTI, 264 Thrd Street, Cambridge, Massachusetts, 02142
- R-TP2** William S. Jewell, Dept. of Industrial Engineering and Operations Research, University of California, Berkeley, Calif.
- R-TP3** E. Frankel, Room 5-326C, MIT, 77 Massachusetts Ave., Cambridge, Mass. 02139
- R-TP4** Richard B. Hoffman, Dept. of Management Science, SUNY, Buffalo, N.Y.
- S-TP1** Ernest Heilberg, Chase, Rosen and Wallace, Inc., 901 N. Washington St. Alexandria, Va.
- R-WA1** William J. Veeder, City Manager, Charlotte, North Carolina 28202
- R-WA2** Alfred Blumstein, School of Urban and Public Affairs, Carnegie-Mellon University, Pittsburgh, Pa.
- R-WA3** Murray Kamrass, IDA, 400 Army-Navy Drive, Arlington, Va. 22202
- R-WA4** Michael Harder, Wisconsin Higher Educational Aids Board, 2218 N. Third St., Milwaukee, Wis.

R-WA5	Bernard M. Levin, Institute for Applied Technology, National Bureau of Standards, Washington, D.C. 20234
S-WA1	John Hornung, CEIR Professional Services Division, Control Data Corp., 5272 River Road, Bethesda, Md. 20014
S-WA2	Sidney Kissen, TRW Systems Group, 1735 I Street, N.W. Washington, D.C.
R-WP1	E. S. Savas, Deputy City Administrator, Office of the Mayor, City of New York, 250 Broadway, New York, N.Y. 10007
R-WP2	Wallace M. Cohen, OPPE, U. W. Office of Education, 400 Maryland Ave, S. W., Washington, D. C.
R-WP3	John P. Young, Homewood Building, Johns Hopkins University, Baltimore, Md. 21218
R-WP4	Robert R. Hare, Department of Mathematics, North Dakota State University, Fargo, N.D.
S-WP1	B. Gordon Smith, GEOMET, Inc., 326 E. Montgomery Ave., Rockville, Maryland 20850

SUMMARY OF EVENTS

	Monday, April 20	AM	Room
R-MA1	Cost Effectiveness in Managing Public Safety	9:00 — 11:30	International Ballroom Center
R-MA2	Evaluating Social Delivery Systems	9:00 — 11:30	Lincoln East
R-MA3	Analysis and Planning of Operations	9:00 — 11:30	Lincoln West
R-MA4	Planning for the Next Decade in Space	9:00 — 11:30	Crystal East
R-MA5	Ladies' Program	9:30 — 11:00	Crystal West
S-MA1	Models for Education	8:45 — 10:00	Jefferson
S-MA2	Quantitative Techniques for Solving Social Problems	10:15 — 11:30	Jefferson
R-MA6	Plenary Session — I	11:30 — 12:30	International Ballroom Center
	Monday, April 20	PM	Room
	LUNCHEON: Presidential Address	12:30 — 2:30	International Ballroom Center
R-MP1	Military OR in the Next Decade	2:30 — 5:00	International Ballroom Center
R-MP2	Cost/Effectiveness Contributed Session	2:30 — 5:00	Lincoln East
R-MP3	Education — I	2:30 — 5:00	Lincoln West
R-MP4	Operations Research in R&D	2:30 — 5:00	Crystal East
R-MP5	Network Flows and Systems	2:30 — 5:00	Crystal West
S-MP1	O.R. and Urban Problems	2:30 — 3:45	Jefferson
S-MP2	Decision Making in Business and Government	4:00 — 5:15	Jefferson
	Tuesday, April 21	AM	Room
R-TA1	Health Applications	9:00 — 11:30	International Ballroom Center
R-TA2	A View of OR and Time-Sharing in the Federal Government	9:00 — 11:30	Lincoln East
R-TA3	Education — II	9:00 — 11:30	Lincoln West
R-TA4	PPBS-Theory and Practice-I	9:00 — 11:30	Thoroughbred
R-TA5	Traffic Safety	9:00 — 11:30	Crystal West
S-TA1	Transportation and Queueing	8:45 — 10:00	Jefferson
S-TA2	Network Analysis	10:15 — 11:30	Jefferson

Tuesday, April 21		PM	Room
	LUNCHEON: Keynote Address	12:00 – 2:00	International Ballroom Center
R-TP1	Connecting Inner-City Residents with Social Service Systems	2:30 – 5:00	International Ballroom Center
R-TP2	Interactive Computing in OR Education	2:30 – 5:00	Lincoln East
R-TP3	Automation, Traffic and Transportation	2:30 – 5:00	Lincoln West
R-TP4	Technological Change in a Social/Political Structure	2:30 – 5:00	International Ballroom West
S-TP1	Military Applications	3:00 – 4:15	Jefferson
	Cocktail Party	6:00 – 8:00	Terrace Level

Wednesday, April 22		AM	Room
R-WA1	City-Minority Group Communication	9:00 – 11:30	International Ballroom Center
R-WA2	Education for OR in the Public Sector	9:00 – 11:30	Georgetown East
R-WA3	Practical Transportation Solutions	9:00 – 11:30	Georgetown West
R-WA4	PPBS-Theory and Practice – II	9:00 – 11:30	Thoroughbred
R-WA5	Validation of OR Models	9:00 – 11:30	Military
S-WA1	Scheduling and Allocation Problems	8:45 – 10:00	Jefferson
S-WA2	Mathematical Programming	10:15 – 11:30	Jefferson
R-WA6	Plenary Session – II	11:30 – 12:30	International Ballroom Center

Wednesday, April 22		PM	Room
R-WP1	The NYC Story	2:00 – 4:30	International Ballroom Center
R-WP2	OR and The Hidden Problems in Education	2:00 – 4:30	Georgetown East
R-WP3	Health Applications Contributed Session	2:00 – 4:30	Georgetown West
R-WP4	Military Applications Contributed Session	2:00 – 4:30	Military
S-WP1	O.R. and Technology	2:00 – 3:15	Jefferson

OTHER ROOM ASSIGNMENTS

Conference Headquarters and Press Room	Kalorama Room
Ladies Hospitality Suite	Chevy Chase Room (April 20, 21)
Ladies Hospitality Suite	Farragut Room (April 22)
ORSA Business Meeting, April 21, 5:00 PM	Lincoln West
ORSA Council	Dupont Room (April 20, 21)
ORSA Council	Grant Room (April 22)
Transportation Science Section	Edison Room
Business Meeting, April 20, 5:00 p.m.	Jefferson Room
Book Exhibit	Hallway

Program/Session Schedule

Sunday April 19		Cocktails 6-10 p.m. Concourse	Georgetown	a.m.	C/E Analysis in Public Safety - IBR Center R-MA1	Eval. Social Delivery Systems - Lincoln E R-MA2	Analysis and Planning of Operations - Lincoln W R-MA3	Planning for Next Decade in Space - Crystal E R-MA4	Ladies' Program 9-30a.m.-11a.m. Crystal W R-MA5	Seminar 8-45 a.m.- 11 30 a.m. Jefferson S-MA1.2	Plenary I
Monday April 20	Registration 8 a.m. - 5 p.m. Concourse	Luncheon 12-30- 2 30 p.m. IBR	Seder 7-9 p.m. Lincoln	9-11 30 p.m. 2 30-5 00	Military OR in Next Dec- ade - IBR Center R-MP1	C/E Contr- buted Session - Lincoln E R-MP2	Education - I Lincoln W R-MP3	OR and R & D Crystal E R-MP4	Network Flows and Systems - Crystal W R-MP5	Seminar 2-30 p.m.- 5 15 p.m. Jefferson S-MP1.2	IBR R-MA6
Tuesday April 21	Registration 8 a.m. - 5 p.m. Concourse	Luncheon 12 00 - 2 00 p.m. IBR	Cocktail Mixer 6-8 p.m. Terrace Level	a.m. 9-11 30 p.m. 2 30-5-00	Health Appl- cations - IBR Center R-TA1	View of OR & Time - Sharing - Lincoln E R-TA2	Education-II Lincoln W R-TA3	PPBS-Theory & Practice-I Thoroughbred R-TA4	Traffic Safety - Crystal W R-TA5	Seminar 8-45 a.m.- 11-30 a.m. Jefferson S-TA1.2	Annual Business Meeting 5-00 p.m. Lincoln
Wednesday April 22	Registration 8 a.m. - 2 p.m. Concourse			a.m. 9-11 30 p.m. 2-4-30	OR and The City - II IBR Center R-WP1	Education for OR in the Public Sector Georgetown E R-WA2	Practical Transportation Solutions - Georgetown W R-WA3	PPBS - Theory & Practice - II Thoroughbred R-WA4	Validation of OR Models Military R-WA5	Seminar 8-45 a.m.- 11-30 a.m. Jefferson S-WA1.2	Plenary II 11:30 a.m.- 12 30 p.m. IBR R-WA6

The architectural floor plan illustrates the layout of the Convention Center. The central feature is the large, circular **EXHIBIT AREA**, which is divided into sections labeled **WEST** and **EAST**. Surrounding the exhibit area are several rooms, including the **CRYSTAL ROOM**, **LINCOLN ROOM**, **JEFFERSON ROOM**, **GEORGETOWN ROOM**, **LEGISLATIVE ROOM**, **HELMUTH/PAUL ROOM**, and **THOMPSON/REED ROOM**. A large **INTERNATIONAL BALLROOM** is located at the bottom of the plan, also divided into **WEST** and **EAST** sections. Other rooms include the **CABINET ROOM**, **CHECK ROOM**, and **RECEPTION** area. The plan also shows the **ENTRANCE** and **EXIT** points, as well as the **LOBBY** and **RESTROOM** facilities. The overall design is modern and functional, with a focus on providing a large, open space for exhibitions and events.

PROGRAM
of the
37th National Meeting

...

Operations Research Society of America

WASHINGTON HILTON HOTEL WASHINGTON, D.C.
April 20-22, 1970

**Operations Research
on Government Problems**

MONDAY AM, APRIL 20

International Ballroom Center

Session: R-MA1 9:00 — 11:30
Cost Effectiveness Analysis and Public Safety
(Sponsored by the Cost Effectiveness Section)

Chairman: ALFRED BLUMSTEIN
School of Urban and Public Affairs, Carnegie-Mellon University, Pittsburgh, Pa.

- R-MA1.1** Participation in Illegitimate Activities — An Economic Approach, *ISAAC EHRLICH, University of Chicago, Graduate School of Business, 5836 Greenwood Ave., Chicago, Ill. 60637.*
- R-MA1.2** Some Resource Allocation Problems in Law Enforcement, *ALBERT M. BOTTOMS, Urban Systems Research and Engineering, Inc., 28 State St., Boston, Mass. 02109.*
- R-MA1.3** Reducing Crime in Apartment Dwellings, *MICHAEL LIECHENSTEIN, The New York City-Rand Institute, 545 Madison Ave., New York, N.Y. 10022.*
- R-MA1.4** Planning Emergency Ambulance Service in an Urban Environment — An Analytical Approach, *KEITH A. STEVENSON, M.I.T. Operations Research Center, Cambridge, Mass.*
Discussant: *DAVID W. CRAIG, Carnegie-Mellon University, Pa.*

MONDAY AM, APRIL 20.

Lincoln East

Session: R-MA2 9:00 – 11:30

Evaluating Social Delivery Systems

(Sponsored by the Washington Operations Research Council)

Chairman. JAMES G. ABERT

Deputy Assistant Secretary for Evaluation and Monitoring, HEW, Wash. D.C. 20201

- R-MA2.1 Evaluating Social Action Programs, JOHN W. EVANS, OEO, Washington, D.C.
- R-MA2.2 The Westinghouse/Ohio University Evaluation of Head Start, VICTOR G. CICIRELLI, University of Wisconsin, Research and Development Center for Cognitive Learning, 1404 Regent St., Madison, Wis. 53706.
- R-MA2.3 Evaluating Community Action Programs: The Measurement and Comparison of 'Hometown Fights', JAMES J. VANECKO, National Opinion Research Center, University of Chicago, Chicago, Ill.
- R-MA2.4 Evaluating Social Action Programs: The Medical Program, VERGIL N. SLEE, M.D., Committee on Professional and Hospital Activities, Ann Arbor, Mich. 48105.

MONDAY AM, APRIL 20

Lincoln West

Session: R-MA3 9:00 – 11:30

Analysis and Planning of Operations

(Sponsored by the Transportation Science Section)

Chairman: E. FARNSWORTH BISBEE

308 Town Bldg., University of Pennsylvania, Philadelphia, Pa. 19104

- R-MA3.1 Intercity Transportation Effectiveness Model, JOHN BASILE, WILLIAM A. JESSIMAN, DONALD E. WARD, DANIEL P. MAXFIELD, Peat, Marwick, Mitchell & Co., Boston, Mass. 02199, and U.S. Department of Transportation.
- R-MA3.2 Practical Algorithms for Scheduling Ground Transportation Systems, PATSY B. SAUNDERS, National Bureau of Standards, Applied Math. Div., Washington, D.C. 20234.
- R-MA3.3 Fleet Size Planning for Unbalanced Stochastic Demands, E. FARNSWORTH BISBEE, University of Pennsylvania, Towne School, Philadelphia, Pa. 19104.
- R-MA3.4 Behavioral Considerations in Modal Split Analysis, LESTER A. HOEL, MICHAEL J. DEMETSKY, Transportation Research Institute, Carnegie-Mellon University, Pittsburgh, Pa. 15213.
- R-MA3.5 Mathematical Models to Predict Travel Demand, RICHARD KU, National Bureau of Standards, Technical Analysis Division, Washington, D.C. 20234.

MONDAY AM, APRIL 20

Crystal East

Session: R-MA4 9:00 - 11:30

Panel on: Planning for the Next Decade in Space
(Sponsored by the Space Sciences Section)

Chairman: PAUL R. SWAN

NASA Mission Analysis Division, Mail Stop 202-9, Moffett Field, Calif. 94035

Panel Discussion

This nation's accomplishments during the last decade can set the high water mark for man's activities in space, or they can be eclipsed by even more significant accomplishments. Whether or not we make full use of the capabilities that we have developed is in essence a free choice. In order to proceed effectively, however, we need the vision to recognize the major questions concerning our future space activities and the perseverance to debate these issues publicly. This panel, with representatives from government, the universities, and industry, will discuss some of the major issues on which a public consensus is needed.

Panel. To be Announced.

MONDAY AM, APRIL 20

Jefferson Room

Session: S-MA1 8:45 - 10:00

Models for Education

Chairman: THEODORE J. WANG

The Institute for Creative Studies, Washington, D.C.

- S-MA1.1 An Activity Information System for the Control of Faculty Workload in a Dynamic University Environment, W. J. FABRYCKY, Virginia Polytechnic Institute, Blacksburg, Va. 24061.
- S-MA1.2 School Bus Routing Via Computers, PAUL L. KINGSTON, IBM, Field Systems Center, 973 James St., Syracuse, N. Y. 13203.
- S-MA1.3 Bus Routing in a Multi-School System, RITA M. NEWTON, Dept. of Industrial Engineering, Bradley University, Peoria, Ill., WARREN H. THOMAS, Dept. of Industrial Engineering, State University of New York at Buffalo, Buffalo, N.Y.
- S-MA1.4 A Mathematical Model for Measurement and Control of Classroom Achievement, PAUL D. PINSKY, Stanford University, Stanford, Calif. 94305.
- S-MA1.5 A Generalized University Model, TIMOTHY W. RUEFLI, Graduate School of Business, B.E.B. 517, University of Texas, Austin, Texas 78712.
- S-MA1.6 A Class Scheduling Model, MILTON E. F. SCHOEMAN, Dept. of Management, GORA BHAUMIK, Dept. of Mechanical Engineering, The University of Texas, Austin, Texas 78712.
- S-MA1.7 RMC's Automated School Cost Model - Developed For and Applied in Planning the New Community of Fort Lincoln, DONALD STROPE, Research Management Corporation, 7315 Wisconsin Ave., Bethesda, Md. 20014.
- S-MA1.8 The Use of a Totally User Oriented Self-Teaching, Interactive Computer Program for Mathematical Problem Solving, MARTIN I. TAFT, Socio-Economic Systems, Inc., 144 North Detroit St., Los Angeles, Calif. 90036.
- S-MA1.9 Micro Level Resource Allocation Models for Universities, ISMAIL B. TURKSEN, ALBERT G. HOLZMAN, University of Pittsburgh, Pittsburgh, Pa.
- S-MA1.10 A Micro Level Forecasting Model of Student Enrollment, ISMAIL B. TURKSEN, University of Pittsburgh, Pittsburgh, Pa., LEO KATZ, Michigan State University, East Lansing, Mich.

- S-MA1.1 A Simulation Model System for Short and Long Range Planning and Budgeting in Health Sciences Education, *R. WILSON, J. R. WALTER, S. JONES, Health Sciences Functional Planning Unit, Univ. of Toronto, Toronto, Canada.*

MONDAY AM, APRIL 20

Jefferson Room

Session: S-MA2 10:15 – 11:30
Quantitative Techniques for Solving Social Problems

Chairman: JOHN R. WARD
GEOMET, Inc., Rockville, Md.

- S-MA2.1 An Investigation of an Adaptive Programming Techniques for the Optimization of Urban Highway Planning Decisions, *JOHN W. DICKEY, Center for Urban and Regional Studies, Virginia Polytechnic Institute, Blacksburg, Va.; MARTIN P. AZOLA, U.S. Air Force, Fairbanks, Alaska.*
- S-MA2.2 A Climatological Model for Forecasting the Demand for Police Service, *NELSON B. HELLER, ROBERT E. MARKLAND, Board of Police Commissioners, 1200 Clark Ave., St. Louis, Mo. 63103.*
- S-MA2.3 Preferences for Response Times to Fires, *RALPH L. KEENEY, M.I.T. and The New York City-Rand Institute, 545 Madison Ave. N.Y. 10022.*
- S-MA2.4 Optimal Transfer Facility Location for Solid Waste Collection, *DAVID H. MARKS, Dept. of Civil Engineering, M.I.T., 1-274 Cambridge, Mass. 02139. JON C. LIEBMAN, Dept. of Geography and Environmental Engineering, The Johns Hopkins University, Baltimore, Md. 21218.*
- S-MA2.5 A Mathematical Programming Model for Water Renovation and Blending for Coastal Cities, *SHISHIR K. MUKHERJEE, Bechtel Corporation, 50 Beale St., San Francisco, Calif.*
- S-MA2.6 Mathematical Programming Applications to Water Quality Planning for the Boston Harbor Region, *JOHN C. SCHAAKE, JR., Dept. of Civil Engineering, MIT 1-276 Cambridge, Mass. 02139.*
- S-MA2.7 Cost-Effectiveness Analysis of Refuse Collection Operations, *TOM SCHAFFER, Operations Research, Inc., 1400 Spring St., Silver Spring, Md. 20910.*
- S-MA2.8 A Quantitative Approach to Urban Problem Analysis, *ROBERT E. SHANNON, RICHARD M. WYSKIDA, Dept. of Industrial and Systems Engineering, University of Alabama in Huntsville, Ala.*
- S-MA2.9 A Systems Approach to Municipal Water Quality Management, *C. S. SEIH, Roy F. Weston Consulting Engineers, West Chester, Pa. 19380; W. L. MEIER, JR., D. S. MILLER, Dept. of Industrial Engineering, Texas A & M Univ., College Station, Texas, 77843.*
- S-MA2.10 Coronary Emergency Rescue Service Treated as a Queuing System, *B. GORDON SMITH, GEOMET, Inc., Rockville, Md.*
- S-MA2.11 The Emergency Medical Service System Model (EMMSSII), *ABIGAIL B. WEMPLE, Operations Research, Inc., 1400 Spring St., Silver Spring, Md., ROBERT R. HARE, N. Dakota State University, Fargo, N.D.*

MONDAY AM, APRIL 20

International Ballroom Center

11:30 – 12:30
Plenary Session: R-MA6
Speaker: To Be Announced

MONDAY PM, APRIL 20

International Ballroom Center

Luncheon, 12:30 – 2:30

Speaker: THOMAS E. CAYWOOD, President

Retiring Presidential Address

Presentation of First Space Sciences Section Award

MONDAY PM, APRIL 20

International Ballroom Center

Session: R-MP1 2:30 – 5:00

Panel on: The Role of Military OR During the Next Decade

(Sponsored by the Military Applications Section)

Chairman: E. W. PAXSON,

Rand Corporation, 1700 Main St., Santa Monica, Calif. 90406

Panel Discussion

Current political and economic considerations are having a pronounced impact on the role of OR/SA in support of the defense establishment. Some of these considerations are transient in character while others will influence the emphasis and direction of future military operations analysis programs over the next decade. This panel will discuss several aspects of this topic in an effort to diagnose what may occur in the coming years and to determine how these trends can be influenced by those active in the military OR community.

Panel: To be announced.

MONDAY PM, APRIL 20

Lincoln East

Session: R-MP2 2:30 – 5:00

Cost/Effectiveness Contributed Session

(Sponsored by the Cost Effectiveness Section)

Chairman: E. S. QUADE, Rand Corporation,
1700 Main St., Santa Monica, Calif. 90406

- R-MP2.1 Cost-Effectiveness Analysis for Emergency Coronary Care Alternatives, J. R. WARD, W. T. TOWLES, B. G. SMITH, GEOMET, Inc., 326 E. Montgomery Ave. Rockville, Md. 20850.
- R-MP2.2 The Transportation Needs of the Rural Poor, JON BURKHARDT, CHARLES EBY, Resource Management Corp., 7315 Wisconsin Ave., Bethesda, Md. 20014.
- R-MP2.3 Cost-Effectiveness Analysis of Civil Engineering Systems: New York City's Primary Water Supply as an Example, RICHARD DE NEUFVILLE, MIT, Cambridge, Mass.
- R-MP2.4 Planning R&D for Maximum Payback, ROBERT L. HAMSON, Merck & Co., Rahway, N. J. 07065.
- R-MP2.5 Multi-Stage Manufacturing AIQL-AOQL Problem from Cost-Effectiveness Point of View, SEDAT SAMI ERCAN, Roosevelt University, 430 S. Michigan Ave., Chicago, Ill. 60605.

MONDAY PM, APRIL 20

Lincoln West

Session: R-MP3 2:30 – 5:00
Education – I

(Sponsored by the Educational Sciences Section)

Chairman: GUSTAVE J. RATH
Northwestern University, Evanston, Ill.

- R-MP3.1 A Mathematical Programming Approach to Designing More Effective and Politically Acceptable School Finance Plans, JAMES BRUNO, University of California, Los Angeles, Calif.
- R-MP3.2 The Optimum Allocation of University Spaces, DUNCAN BAILEY, PAUL HAMELMAN, CHARLES SCHOTTA, University Polytechnic Institute, Blacksburg, Va.
- R-MP3.3 A Model of the Funding Decision-Making Process, YING C. CHUANG, Center for Urban Education, New York, N.Y.
- R-MP3.4 A Computer Simulation Approach to Enrollment Projection in Higher Education, ALLEN BAISUCK, Rensselaer Research Corp., Troy, New York, WILLIAM A. WALLACE, Rensselaer Polytechnic Institute, Troy, N.Y.

MONDAY PM, APRIL 20

Crystal East

Session: R-MP4 2:30 – 5:00
Operations Research in R & D

Chairman: BURTON V. DEAN
School of Management, Case Western Reserve Univ., Cleveland, Ohio 44106

- R-MP4.1 Manpower Planning and Project Progress Measurement, CHARLES E. JONES, ROBERT H. CULHAN, Babcock & Wilcox Company, Alliance, Ohio.
- R-MP4.2 Evaluation of New Product Facilities Under Best Price, Marketing Effort, and Expansion Phasing Systems, MEYER KLEIN, Dow Chemical Company, Midland, Mich.
- R-MP4.3 Planning and Control Techniques for Applied Research, WILLIAM E. SOUDER, Monsanto Chemical Company, St. Louis, Mo.
- R-MP4.4 Exploratory Development Project Evaluation, BURTON V. DEAN, Case Western Reserve University, Cleveland, Ohio, LEWIS A. ROEPCKE, Army Materiel Command, Washington, D.C.

MONDAY PM, APRIL 20

Crystal West

Session: R-MP5 2:30 - 5:00
Network Flows and Systems

Chairman: HOWARD FRANK

Network Analysis Corporation, Beechwood, Old Tappen Rd., Glen Cove, N.Y. 11542

- R-MP5.1 Measurement and Modeling of the ARPA Computer Network, *L. KLEINROCK, Department of Computer Sciences, UCLA, Los Angeles, Calif.*
- R-MP5.2 Application of Flow Methods to Power Distribution, *S. D. CHAUBEY, Department of Electrical Engineering and Computer Sciences, University of California, Berkeley, Calif., I. T. FRISCH, Network Analysis Corp., Glen Cove, N.Y.*
- R-MP5.3 Survivable Networks with Priorities, *W. CHOU, Network Analysis Corp., Glen Cove, N.Y.*
- R-MP5.4 One Terminal Telpak Optimization, *B. ROTHFARB, Network Analysis Corp., Glen Cove, N.Y. M. GOLDSTEIN, Office of Emergency Preparedness, Washington, D.C.*
- R-MP5.5 Optimal Design of Offshore Natural Gas Pipeline Systems, *B. ROTHFARB, Network Analysis Corp., Glen Cove, N.Y., H. FRANK, Network Analysis Corp., Glen Cove, N.Y., K. STEIGLITZ, Dept. of Electrical Engineering, Princeton University, Princeton, N.J., D. J. KLEITMAN, Dept. of Mathematics, MIT, Cambridge, Mass.*

MONDAY PM, APRIL 20

Jefferson Room

Session: S-MP1 2:30 - 3:45
O.R. and Urban Problems

Chairman: GORDON B. PAGE

Research Associates, Inc., Silver Spring, Md.

- S-MP1.1 Education for Operations Research in Urban and Regional Planning, *HERMAN G. BERKMAN, AIP, Prof. of Planning, Graduate School of Public Administration, New York University, New York, N.Y.*
- S-MP1.2 Sociological Goals and Curriculum Content in Education, *C. J. HARRIS, General Electric Co., Environmental Sciences Lab., Valley Forge, Pa.*
- S-MP1.3 Moon Shots Won't Stop Riots, *DONALD E. HUNTER, Marcou, O'Leary and Associates, 1735 K St., N.W., Washington, D.C.*
- S-MP1.4 The Quality of Urban Life in the United States - A Study of Urban Indicator Methodology and Presentation, *MARTIN V. JONES, MICHAEL J. FLAX, The Urban Institute, 2100 M St., N.W., Washington, D.C. 20037.*
- S-MP1.5 Quantitative Assessment of the Concentrated Employment Program, *W. J. LEININGER, Operations Research, Inc., 1400 Spring St., Silver Spring, Md. 20910.*
- S-MP1.6 Study of the Need for Educational Manpower for Handicapped Children and Youth, *RAY MINTZ, Operations Research, Inc., 1400 Spring St., Silver Spring, Md. 20910.*
- S-MP1.7 Criteria Weighting: Inter-Method Stability and Consistency of Preference in an Urban Planning Application, *CHARLES C. SCHIMPELER, Louisville & Jefferson County Air Board, P.O. Box 21176, Louisville, Ky. 40221, NORMAN R. BAKER, Georgia Institute of Technology, Atlanta, Ga., WILLIAM GRECCO, School of Civil Eng., Purdue Univ., W. Lafayette, Ind.*
- S-MP1.8 Environmental Quality and Environmental Pollution: Some Problems of Definition, Classification and Measurement, *ROBERT B. SHAIN, Kelly Scientific Corp., 3900 Wisconsin Ave., N.W., Washington, D.C. 20016.*

- S-MP1.9 Community Education Planning in Anacostia, Washington, D.C., *DONALD STROPH, Resource Management Corp., 7315 Wisconsin Ave., Beth., Md. 20014.*
- S-MP1.10 Systematic Evaluation and Allocation of United Community Welfare Funds to Various Programs, Agencies and Services, *MARTIN I. TAFT, Socio-Economic Systems, Inc., 144 N. Detroit St., Los Angeles, Calif. 90036.*
- S-MP1.11 Extensions of Activity Allocation Models in Urban Planning, *RICHARD D. WORRALL, Peat, Marwick, Mitchell & Co., 1025 Connecticut Ave., N.W., Washington, D.C. 20036.*

MONDAY PM, APRIL 20

Jefferson Room

Session: S-MP2 4:00 — 5:15
Decision Making in Business and Government

*Chairman: HARRY WEINTROB
Leasco Systems and Research, Bethesda, Md.*

- S-MP2.1 Governmental vs. Non-Governmental Conflict Resolution, *A. CAROL, Dept. of O.R. Systems Analysis, Polytechnic Institute of Brooklyn, Brooklyn, N.Y. 11201.*
- S-MP2.2 Marginal Stockholder Tax Brackets and the Clientele Effect, *EDWIN J. ELTON, MARTIN J. GRUBER, New York University, Graduate School of Business Administration, 100 Trinity Place, New York, N.Y. 10006.*
- S-MP2.3 The Application of Decision Analysis to Multiple Sourcing of R & D, *VICTOR FUNG, WARREN BRIGGS, Harbridge House, Inc., Boston, Mass.*
- S-MP2.4 O.R.-Based Interactive Financial Performance Analysis, *J. C. GRACE, Bethlehem Steel Corp., Bethlehem, Pa.*
- S-MP2.5 The Optimal Deductible for a Given Automobile Insurance Policy, *CHRISTOPH HAEHLING VON LANZENAUE, School of Business Administration, University of Western Ontario, London 72, Canada.*
- S-MP2.6 Capital Budgeting in Continuous Time, *ALAN K. HALDER, Dept. of O.R. and I.E., Johns Hopkins University, Baltimore, Md. 21218.*
- S-MP2.7 When is a Property "Measurable"? *PHILIP HAYWARD, The John D. Kettelle Corp. 1701 N. Ft. Meyer Drive, Arlington, Va. 22209.*
- S-MP2.8 Alternative Player Types in Games, *LAMBERT S. JOEL, Applied Math. Division, National Bureau of Standards, Washington, D.C. 20234.*
- S-MP2.9 A Heuristic Model for the Calculation of Indirect Costs Required on Projects—Uses in Contract Bidding Purposes, *TÜRKÂN E. KUMBARACI, Dept. of Industrial Engineering, Middle East Technical University, Ankara, Turkey.*
- S-MP2.10 Political Science Applications of Nonmetric Multidimensional Scaling, *SUBRATA K. SEN, Graduate School of Business, University of Texas, Austin, Texas 78712.*
- S-MP2.11 Diagnostic Criteria for Evaluation of Health of Laboratory Organizations, *ELDON E. SWEEZY, Management Counsel, 8007 Kentbury Drive, Bethesda, Md. 20014.*

TUESDAY AM, APRIL 21

International Ballroom Center

Session: R-TA1 9:00 - 11:30
Health Applications
(Sponsored by the Health Applications Section)

Chairman: CHARLES D. FLAGLE
School of Hygiene and Public Health, The Johns Hopkins
University, 615 N. Wolfe St., Baltimore, Md. 21205

- R-TA1.1 Dynamic Planning of Health Care Systems, G. G. LOVE, R. A. MATHIAS, G. TREBBI, *Westinghouse Electric Corp., Pittsburgh, Pa. 15235.*
- R-TA1.2 Toward an Integrated Methodology for the Analysis of Health Care Systems, RICHARD D. SMALLWOOD, *Stanford University, Stanford, Calif.*
- R-TA1.3 Decision Theoretic Approach to Measuring Burned Patient Severity, DAVID GUSTAFSON, *University of Wisconsin, Madison, Wis.*
- R-TA1.4 Medicaid Information System as a Tool for Management, R. J. SALMON, *Dept. of Health, Education and Welfare, Washington, D.C.*, R. SWID, *Booz, Allen and Hamilton, S. GERSHENSON, BASYS, Inc., S. GARDNER, BASYS, Inc.*

TUESDAY AM, APRIL 21

Lincoln East

Session: R-TA2 9:00 - 11:30
A View of OR and Time-Sharing in The Federal Government

Chairman: HUGH V. O'NEILL
GE/TEMPO, 777 14th St., N.W. Washington, D.C. 20005

- R-TA2.1 Overview of Time-Sharing for Decision Making in the Department of Defense, HENRY A. LICHSTEIN, *Dept. of Defense, Washington, D.C. 20301.*
- R-TA2.2 Cost-Benefit Analysis of Biomedical Information and Communications Services, RUTH M. DAVIS, *National Library of Medicine, 8600 Rockville Pike, Bethesda, Md. 20014.*
- R-TA2.3 A Time-Sharing System for Congress, ROBERT L. CHARTRAND, *Library of Congress, Washington, D.C. 20540.*
- R-TA2.4 The Potential of Cost-Benefit Analyses to Support Federal Government Policy Making in the Area of Time-Sharing and Data Banks, MICHAEL GOLD, *University of Pittsburgh, Pittsburgh, Pa. 15213.*

TUESDAY AM, APRIL 21

Lincoln West

Session: R-TA3 9:00 - 11:30
Education - II
(Sponsored by the Educational Sciences Section)

Chairman: WILLIAM DORFMAN
Room 1187A, Office of Education, 400 Maryland Ave., SW, Washington, D.C.

- R-TA3.1 Implementing PPBS in Elementary Schools, GUSTAVE J. RATH, *Northwestern University, Evanston, Ill. 60201.*
- R-TA3.2 A Cost-Benefit Analysis of University Year-Round Operations, DAVID S. P. HOPKINS, *University of California, Berkeley, Calif. 94700.*
- R-TA3.3 Emerging Concepts in Education, THOMAS J. BURNS, *U.S. Office of Education, Washington, D.C.*
- R-TA3.4 Implementing the CAMPUS Models and Related Techniques, RICHARD W. JUDY, *University of Toronto, Toronto, Canada.*

TUESDAY AM, APRIL 21

Thoroughbred

Session: R-TA4 9:00 – 11:30
PPBS – Theory and Practice I

Chairman: MIKLOS WASS DE CZEGE
Department of Public Instruction, Madison, Wis. 53702

- R-TA4.1 Towards a PPB Theory, *MIKLOS WASS DE CZEGE, Dept. of Public Instruction, Madison, Wis. 53702.*
- R-TA4.2 Comparative Analysis of PPB Development in the United States, *MICHEL RAUD, Ecole Hec, Jovy-in-Josas, France.*
- R-TA4.3 PPBS and the Politics of the Budgeting Process, *THOMAS CZEWINSKI, Bureau of Budget, State of Illinois, Springfield, Ill.*
- R-TA4.4 Command, Coordination, and Control in PPB, *MIKLOS WASS DE CZEGE, Dept. of Public Instruction, Madison, Wis. 53702.*
- R-TA4.5 Strategy for Implementing PPB in a State Government, *DICK ROSS, Bureau of State Planning, Madison, Wis. 53702.*
- R-TA4.6 Strategy for Implementing PPB in a Developing Nation, *CHARLES OBEL-OMIA, Uganda Institute of Public Administration, Kampala, Uganda.*

TUESDAY AM, APRIL 21

Crystal West

Session: R-TA5 9:00 – 11:30
Traffic Safety

Chairman: PAUL GRAY
Stanford Research Institute, Menlo Park, Calif. 94025

- R-TA5.1 Research Strategy for Highway Safety, *HUGH J. MISER, University of Massachusetts, Amherst, Mass. 01002.*
- R-TA5.2 Causal Chain Approaches to the Evaluation of Highway Safety Countermeasures, *WILLIAM K. HALL, JAMES O'DAY, The University of Michigan, Highway Safety Research Institute, Ann Arbor, Mich.*
- R-TA5.3 The Reduction of Traffic Accident Fatalities by Crash Phase Countermeasures, *HANS C. JOKSCH, The Travelers Research Corp., 250 Consitution Plaza, Hartford, Conn. 06103.*
- R-TA5.4 An Empirically Based Method of Allocating the Highway Safety Budget, *RICHARD D. HEILBRON, WILLIAM LEININGER, Leasco Systems and Research Corp., 4833 Rugby Ave., Bethesda, Md. 20014.*
- R-TA5.5 Comparison of Psychological-Biographical Characteristics of Drinking Drivers from Crash, Citation, and Roadblock Control Samples, *M. W. PERRINE, University of Vermont, Burlington, Vt. 05401.*
- R-TA5.6 Highway Safety Research at the Institute of Transportation and Traffic Engineering at UCLA, *HARRY W. CASE, Institute of Transportation and Traffic Engineering, University of California, Los Angeles, Calif.*

TUESDAY AM, APRIL 21

Jefferson Room

Session: S-TA1 8:45 - 10:00
Transportation and Queuing

Chairman: WILLIAM BILLION
Military Traffic Management and Terminal Service,
Baileys Crossroads, Va.

- S-TA1.1 Problems in Measuring Transportation Impedances, *JANE DUBERG, National Bureau of Standards, Washington, D.C. 20234.*
- S-TA1.2 Queuing with Control on the Arrival of Certain Type of Customers, *MECKINLEY SCOTT, University of Alabama, University, Ala. 35486.*
- S-TA1.3 Use of Psychological Scaling Techniques in Transportation Problems, *KENNETH W. HEATHINGTON, Purdue University, School of Engineering, W. Lafayette, Ind. 47907.*
- S-TA1.4 Study of Safety Standards and Motor Vehicle Inspection Requirements for Used Motor Vehicles, *STANLEY KALIN, Operations Research, Inc., 1400 Spring St., Silver Spring, Md. 20910.*
- S-TA1.5 Environmental and Social Cost Impacts of Transportation System Technologies, *ARMANDO M. LAGO, Resource Management Corp., 7315 Wisconsin Ave., Bethesda, Md.*
- S-TA1.6 The Traffic Loss at a Merge-Point Controlled by Non-Feedback Regulation, *JOEL LEVY, MARTIN H. PEARL, Applied Mathematics Division, NBS, Washington, D.C. 20234.*
- S-TA1.7 A New Class of Models for the Modal Split of Transportation Demand, *D. E. VAN TIJN and E. DAVID ABRAMS, The John D. Kettelle Corp., 1770 Lancaster Pike, Paoli, Pa. 19301.*
- S-TA1.8 Decomposing a Traffic Control Problem, *J. B. WILLIAMS, Boeing Company, Aerospace Systems Div., P.O. Box 3999, Seattle, Wash. 98124.*
- S-TA1.9 Two Measures for Describing Queue Behavior, *U. NARAYAN BHAT, Computer Sciences Center, Institute of Technology, Southern Methodist University, Dallas, Texas 75222.*
- S-TA1.10 Serial Queues with Interference, *IRWIN W. KABAK, New York University, Graduate School of Business Administration, 100 Trinity Place, New York, N.Y. 10006.*

TUESDAY AM, APRIL 21

Jefferson Room

Session: S-TA2 10:15 - 11:30
Network Analysis

Chairman: RIC BLACKSTEN
Mathematica, Bethesda, Md.

- S-TA2.1 Simple Bounds with Application in Stochastic Critical Path Analysis, *ROBERT A. AGNEW, AFITSE-S, Wright Patterson AFB, Ohio 45433.*
- S-TA2.2 Optimum-Path Algorithms Applications in Transport Operations Analysis and Management, *WILLIAM D. CASSIDY, Office of the Secretary of Transportation, TPI-10, Washington, D.C. 20590.*
- S-TA2.3 The Backtracking Method of Solving the General Multi-Commodity Flow Problem, *HANNAH CHEN, CHARLES G. DE WALD, Dept. of Industrial Engineering, State Univ. of New York at Buffalo, Buffalo, N.Y. 14214.*
- S-TA2.4 Congestion Analysis of Dynamic Flow Networks An Operational Approach, *CHARLES G. DE WALD, Dept. of Industrial Engineering, State Univ. of New York at Buffalo, Buffalo, N.Y. 14214.*

- S-TA2.5 Minimum Cost Flows, Negative Cycles and Positive Loops, *MICHAEL FLORIAN, PIERRE ROBERT, MAURICE ROSSIN-ARTHIAT, University of Montreal, Canada.*
- S-TA2.6 A Computer Comparison of Labelling Algorithms for Calculating Shortest Path Trees, *JUDITH F. GILSINN, Applied Math Division, NBS, Washington, D. C. 20234, CHRISTOPH WITZGALL, Boeing Scientific Research Labs., Seattle, Wash.*
- S-TA2.7 Optimizing Sorting Networks, *WILLIAM A. HORN, Applied Math. Division, NBS, Washington, D.C. 20234.*
- S-TA2.8 A Sequential Deletion Algorithm for the Design of Optimal Transportation Networks, *ARTHUR D. O'CONNOR, Cornell Aeronautical Laboratory, Inc., P.O. Box 235, Buffalo, N.Y. 14221, CHARLES G. DE WALD, Parker Engineering, State Univ. of New York at Buffalo, Buffalo, N.Y. 14214.*
- S-TA2.9 Enumerative Algorithms for Solving a Class of Network Synthesis Problems, *ROBERT D. SANDERSON, Fair Isaac and Co., Inc., 55 Mitchell Blvd., San Rafael, Calif. 94903.*
- S-TA2.10 The Fixed Charge Network Problem, *BERNARD YAGED, JR. Bell Telephone Laboratories, Inc., Holmdel, N.J.*
- S-TA2.11 Finding the K Shortest Loopless Paths in a Network, *JIM Y. YEN, 4660 Harbord Drive, Oakland, Calif. 94618.*

TUESDAY PM, APRIL 21

International Ballroom Center

Luncheon 12:00 – 2:00
Speaker to be announced

TUESDAY PM, APRIL 21

International Ballroom Center

Session: R-TP1 2:30 – 5:00

OR and The City – I

Panel on: Connecting Inner-City Residents with Social Service Systems

Chairman: EVELYN F. MURPHY
OSTI, 264 Third St., Cambridge, Mass. 02142

An informal panel discussion on the issue of connecting social service systems with people who have not previously been connected with such systems will be held. Experiences with community groups on Detroit, Hartford, Newark, and Racine will form the basis for initiating the discussion. The session will highlight relevant and critical community needs as a source of criteria for OR and systems studies, and will emphasize relevance and action

Panel: *REGINALD ROBINSON, OSTI, 264 Third St., Cambridge, Mass. 02142; JOANNE A. ROSS, 2 Brandon Ave., Dorchester, Mass.; REGINALD C. WELLS, New Opportunities for Waterbury, Inc., 769 N. Main St., Waterbury, Conn.*

TUESDAY PM, APRIL 21

Lincoln East

Session: R-TP2 2:30 - 5:00
Interactive Computing in OR Education
(Sponsored by the ORSA Education Committee)

Chairman: WILLIAM S. JEWELL

Dept. of Industrial Engineering and Operations Research, University of
California, Berkeley, Calif.

- R-TP2.1 Computer Aided Laboratories in Inventory Systems, E. NADDOR, *The Johns Hopkins University, Baltimore, Md.*
- R-TP2.2 Operations Research and Computer Science—The Interface, R. E. NANCE, *Southern Methodist University, Dallas, Texas.*
- R-TP2.3 OSCAR—An Interactive Language: Instructional Use in Operations Research and Statistics, V. JOSEPH BOWMAN, JR., *Oregon State University, Corvallis, Ore. 97331.*
- R-TP2.4 Interactive Computing in Operations Research Education at the Graduate School of Industrial Administration, Carnegie-Mellon University, G. L. THOMPSON, D. P. GAVAR, *Carnegie-Mellon University, Pittsburgh, Pa.*

Panel discussion to follow the formal papers.

TUESDAY PM, APRIL 21

Lincoln West

Session: R-TP3 2:30 - 5:00
Automation, Traffic, and Transportation
(Sponsored by the Transportation Science Session)

Chairman: E. FRANKEL

Room 5-326C, MIT, 77 Massachusetts Ave., Cambridge, Mass. 02139

- R-TP3.1 Mathematical Methods of Optimization for Multi-Objective Transportation Systems, K. C. KAPUR, *Research Lab., Warren, Mich. 48090.*
- R-TP3.2 A Time Dependent Modal Split Model for Computers, WALTER HELLY, ISRAEL PRESSMAN, HARRY YAGODA, *Polytechnic Institute of Brooklyn, 333 Jay St., Brooklyn, N.Y. 11201.*
- R-TP3.3 Estimating Automated Network Grid Spacings Which Minimize Costs, M. B. GODFREY, *MIT, Cambridge, Mass. 02139.*
- R-TP3.4 Isolation of Speed Effects and Capacity Effects of Efficiency of Cargo Ships, R. L. HAMSON, *Operations Research, Merck and Co., Inc., Rahway, N.J. 07065.*
- R-TP3.5 Optimal Location of Intermediate Facilities in a Transshipment Network, D. H. MARKS, *MIT, Cambridge, Mass. 02139.* J. C. LIEBMAN, *The Johns Hopkins University, Baltimore, Md. 21218.* M. BELLMORE, *The Johns Hopkins University, Baltimore, Md. 21218.*
- R-TP3.6 Solution of Multi-Mode Traffic Assignment Problems by the Duoplex Method, M. J. BECKMAN, *Dept. of Economics, Brown University, Providence, R.I. 02912.* H. P. KÜNZI, *Zurich, Switzerland.*
- R-TP3.7 The Development and Use of a Model for Cargo Load Planning, J. C. TENNANT, *Air Canada, Dorval, Quebec.*
- R-TP3.8 Analytical Models for Air Terminal Design, J. M. BRUGGEMAN, R. D. WORRALL, *Peat, Marwick, Mitchell & Co., 1025 Connecticut Ave., N.W., Washington, D.C. 20036.*

TUESDAY PM, APRIL 21

International Ballroom West

Session: R-TP4 2:30 — 5:00

Technological Change in a Social/Political Structure

Chairman: RICHARD B. HOFFMAN

Dept. of Management Science, SUNY, Buffalo, N.Y.

- R-TP4.1 Bureaucratic Rewards as a Constraint Upon Technological Innovation, RICHARD B. HOFFMAN, State University of New York, Buffalo, N.Y.
- R-TP4.2 Some Effects of Changing Technology Upon the Organization of Scientific Inquiry, L. VAUGHN BLANKENSHIP, State University of New York, Buffalo, N.Y.
- Discussants: LESLIE WILKINS, State University of New York at Albany, and GORDON E. MISNER, University of Missouri, St. Louis, Mo.
- R-TP4.3 Technology Encounters Bureaucracy: Change in the New York Fire Department, RAE W. ARCHIBALD, The New York City-RAND Institute, 545 Madison Ave., New York, N. Y.
- R-TP4.4 Discussion Panel: DIETER HAUSSMAN, McKinsey and Company, New York, N.Y. JOHN T. O'HAGAN, Chief, Fire Department, New York City, S. ROSENBLUM, Harvard University, Cambridge, Mass.

TUESDAY PM, APRIL 21

Jefferson Room

Session: S-TP1 3:00 — 4:15

Military Applications

Chairman. ERNEST HEILBERG

Chase, Rosen and Wallace, Inc., Alexandria, Va.

- S-TP1.1 The Optimal Allocation of MIRV Missiles, JOE BARTLETT, Operations Research, Inc., 1400 Spring St., Silver Spring, Md. 20910.
- S-TP1.2 Simulation as a Methodology for Integrating the Management Decision Process in Naval Aviation, F. J. BELLAR, JR., Weapon Systems Analysis Office, Bldg. 220, Room 212-A, Washington Navy Yard, Washington, D.C. 20390; F. M. NELSON, Resource Management Corp., 7315 Wisconsin Ave., Bethesda, Md.
- S-TP1.3 Futurology and Military Analysis, JOSEPH BODO, Sylvania Electronic Defense Labs., Box 205, Mountain View, Calif. 94042.
- S-TP1.4 Recruit Assignment Model, EARL E. BROWN, Data Systems Div. (AP11), U. S. Marine Corps, HQ, Washington, D. C. 20380.
- S-TP1.5 Integrated Facility Requirements Study (IFRS), TOM KYLE, Operations Research, Inc., 1400 Spring St., Silver Spring, Md. 20910.
- S-TP1.6 Design Logistic Integration Control Method for Integrated Logistic Support Program Application, DON MANAHAN, Operations Research, Inc., 1400 Spring St., Silver Spring, Md. 20910.
- S-TP1.7 A Model for Single Searcher Sweep Rates and its Application, R. MCCALLUM, Operations Research, Inc., 1400 Spring St., Silver Spring, Md. 20910.
- S-TP1.8 Quantitative Analysis of the Dynamics of Fire and Maneuver, C. W. PATTEN, Operations Research, Inc., 1400 Spring St., Silver Spring, Md. 20910.
- S-TP1.9 Lanchester-Type Models of Warfare and Optimal Control, J. G. TAYLOR, Naval Postgraduate School, Monterey, Calif.
- S-TP1.10 Optimal Flight Paths over a Surface-to-Air Missile Threat Area, D. TERRIS, Autonetics Div., North American Rockwell Corp., 3370 E. Miraloma, Anaheim, Calif.
- S-TP1.11 Military Applications of Large-Scale Mathematical Programming Models Description and Critique, JUSTIN C. WHITON, Management Science Systems, 1530 East Jefferson St., Rockville, Md. 20852.

TUESDAY PM, APRIL 21

Lincoln West

5:00 PM

Annual Business Meeting of the Society

WEDNESDAY AM, APRIL 22

International Ballroom Center

Session: R-WA1 9:00 — 11:30

OR and The City — II

City — Minority Group Communication

Chairman: WILLIAM J. VEEDER

City Manager, Charlotte, N.C. 28202

The session is a panel discussion among city managers and representatives of minority groups addressed to joint solutions of problems. In this respect, communication assumes major importance. Topics to be covered include a definition of communication channels, identification of things to be communicated, issues to be communicated upon, the process of finding consensus, communication among agencies of the city government, communications among subsections of the city, and the unstated values and assumptions that dominate the problems.

Panel. PICOT FLOYD, City Manager, Savannah, Ga., LEON EPLAN, Eric Hill Associates, 75 8th St., NE, Atlanta, Ga., JOHN PARKER, Parklow Associates, Inc., 12250 Wilkins St., Rockville, Md.

WEDNESDAY AM, APRIL 22

Georgetown East

Session: R-WA2 9:00 — 11:30

Education for Operations Research in The Public Sector

Chairman: ALFRED BLUMSTEIN

School of Urban and Public Affairs, Carnegie-Mellon Univ., Pittsburgh, Pa.

R-WA2.1 Conjectures on Operations Research Education, *SETH BONDER, University of Michigan, Ann Arbor, Mich. 48104.*

R-WA2.2 Introduction of Problem Orientation in an Engineering-Economic Systems Program, *WILLIAM K. LINVILL, Stanford University, Palo Alto, Calif.*

R-WA2.3 Education for Operations Research in the Public Sector.

Panel Discussion. Participants, *SETH BONDER, University of Michigan, JACK BORSTING, Naval Postgraduate School, WILLIAM LINVILL, Stanford University, JOHN D. C. LITTLE, MIT, E. S. SAVAS, Deputy City Administrator, New York City.*

WEDNESDAY AM, APRIL 22

Georgetown West

Session: R-WA3 9:00 — 11:30

Practical Transportation Solutions

(Sponsored by the Washington Operations Research Council)

Chairman: MURRAY KAMRASS

IDA, 400 Army-Navy Drive, Arlington, Va. 22202

- R-WA3.1 A Multi-Variate Analysis of Factors Affecting Transit Bond Referendums, *ARMANDO M. LAGO, Resource Management Corp., 7315 Wisconsin Ave. Bethesda, Md. 20014.*
- R-WA3.2 Planning and Considerations for the Mexico City Metro, *BERNARDO QUINTANA, President, ICA, Mexico City, Mexico.*
- R-WA3.3 Political Acceptability and Economic Feasibility of Center City Transportation Systems, *JANE-RING CRANE, ELIZABETH PARKER, IDA, 400 Army-Navy Drive, Arlington, Va. 22202.*
- R-WA3.4 An Approach to Resolving the Transportation Impasse, *CHARLES F. BARNES, JR., Alan M. Voohees and Associates, Westgate Research Park, McLean, Virginia 22101.*

WEDNESDAY AM, APRIL 22

Thoroughbred

Session: R-WA4 9:00 — 11:30

PPBS — Theory and Practice — II

Chairman: MICHAEL HARDER

Wisconsin Higher Educational Aids Board, 2218 N. Third St. Milwaukee, Wis.

- R-WA4.1 Planning in PPBS, *MIKLOS WASS DE CZEGE, Dept. of Public Instruction, Madison, Wis. 53713.*
- R-WA4.2 Participatory Planning in a Structured Environment; Planning for the Management of the State Educational Agency, *NED WETMORE, Bureau of State Planning, Madison, Wis. 53713.*
- R-WA4.3 Participatory Planning in an Unstructured Environment, Planning for a Transitional Education Program, *MICHAEL HARDER, Wisconsin Higher Educational Aids Board, 2218 N. Third St. Milwaukee, Wis.*
- R-WA4.4 Organization in PPBS, *MIKLOS WASS DE CZEGE, Dept. of Public Instruction, Madison, Wis. 53713.*
- R-WA4.5 Organization for Management Decisionmaking: The Development of a PPB Problem Oriented Budget, *PHILIP SALISBURY, Institute of Poverty Research, Ames, Iowa.*
- R-WA4.6 Organization for Management Decisionmaking: The Development of a PPB Decision Scenario, *LARRY HAMILTON, Colorado Commission on Higher Education, Denver, Colo.*

WEDNESDAY AM, APRIL 22

Military

Session: R-WA5 9:00 — 11:30
Panel on: Validation of OR Models

Chairman: BERNARD M. LEVIN
Institute for Applied Technology, NBS,
Washington, D.C.

Panel Discussion: OR models (including simulation, analytic, econometric, and statistical models) provide predictions which serve as a basis for making management decisions. The quality of these decisions depend upon the accuracy of the predictions. Validity of models is a major factor in ascertaining the amount of reliance that should be placed on their predictions. By validity is meant the degree to which the model behaves as the system being modeled. Estimating validity or verifying models is an important but neglected area. The panel will discuss the problem from both a philosophical and practical viewpoint, including specific cases.

Panel: JACK MOSHMAN, *Resource and Management Systems Corp., 6400 Goldsboro Road, Washington, D.C. 20034*, HUGH MISER, *Dept. of Industrial Engineering, University of Massachusetts, Amherst, Mass. 01002*, ERNEST KOENIGSBERG, *Matson Research Corp., 215 Market St., San Francisco, Calif. 94105*.

WEDNESDAY AM, APRIL 22

Jefferson Room

Session: S-WA1 8:45 — 10:00
Scheduling and Allocation Problems

Chairman: JOHN HORNUNG
CEIR Professional Services Div.,
Control Data Corp., Bethesda, Md.

- S-WA1.1 Scheduling Problems at a Time-Sharing Computing Center, *SANT R. ARORA, AMARLAL KALRO, Univ. of Minnesota, 125 Mechanical Engineering Bldg., Minneapolis, Minn. 55455*.
- S-WA1.2 Job-Shop Scheduling With the Branch-and-Bound Approach, *SAID ASHOUR, S. R. HIREMATH, Dept. of Industrial Engineering, Kansas State University, Manhattan, Kansas*.
- S-WA1.3 The Scheduling of Resource Constrained Activities, *J. S. CLARK, Wolf Research and Development Corp., Riverdale, Md. 20840*.
- S-WA1.4 Optimal Control of a Maintenance System with Variable Service Rates, *THOMAS B. CRABILL, University of North Carolina, Chapel Hill, N. C. 27514*.
- S-WA1.5 Economic Aspects of Scheduling Theory, *JATINDER N. D. GUPTA, Dept. of Industrial and Systems Engineering, University of Alabama in Huntsville, Huntsville, Ala.*
- S-WA1.6 A Simulation of a Highway Maintenance Depot, *WILLIAM G. HALL, Applied Math. Division, NBS, Washington, D.C. 20234*
- S-WA1.7 Algorithm and Analysis of Multi-Resources Allocation, *M. USMAN KHAN, Boeing Co., P.O. Box 3707, Seattle, Wash. 98124*.
- S-WA1.8 Optimal Resource Allocation/Leveling in Engineering/Construction Projects, *T. PRABHAKAR, Scientific Applications, P.O. Box 8004, Bldg. 82-510, South Charleston, W. Va. 25303*.
- S-WA1.9 An Implicit Enumeration Approach to the Optimal Solution of the Three-Machine Scheduling Problem, *ASHOK RAO, Rensselaer Polytechnic Institute, Troy, N.Y. 12181*.

- S-WA1.10 Efficient Solutions of the Resource Constrained Scheduling and Assignment Problem, *ROBERT W. L. THOMAS, Wolf Research and Development Corp., Riverdale, Md. 20840.*
- S-WA1.11 A Continental Oil and Gas Supply and Distribution Model, *JOSEPH G. DEBANNE, University of Ottawa, Ontario, Canada.*

WEDNESDAY AM, APRIL 22

Jefferson Room

Session: S-WA2 10:15 – 11:30
Mathematical Programming

Chairman: SIDNEY KISSEN
TRW Systems Group, Washington, D.C.

- S-WA2.1 An Exposition of the Group Theoretic Approach to Integer Linear Programming, *DER-SAN CHEN, STANLEY ZOINTS, State University of New York at Buffalo, Buffalo, N.Y. 14214.*
- S-WA2.2 Minimax-Error Disaggregation of a Distribution, *A. J. GOLDMAN, NBS, Washington, D.C. 20234.*
- S-WA2.3 A Computational Study of Dimensionality Reduction Methods in Dynamic Programming, *ALBERT GRAY, W. L. MEIER, JR., Texas A & M University, College Station, Texas 77843.*
- S-WA2.4 On Construction of Reference Equation in Simplified All Integer Primal Algorithm, *D. K. GUHA, New York Port Authority, 111 Eighth Ave., New York, N.Y. 10011.*
- S-WA2.5 A Search Model for Evaluating Combinatorially Explosive Problems, *KEITH L. MCROBERTS, Iowa State University, Ames, Iowa 50010.*
- S-WA2.6 Staff Assignment Under Risk – Some Solvable Nonlinear Zero-One Problems, *GERHARD MENSCH, Tulane University, New Orleans, La. 70118.*
- S-WA2.7 Generalized Lagrange Multipliers and Linear Programming, *G. L. NEM-HAUSER, The Johns Hopkins University, Baltimore, Md. 21218; W. B. WIDHELM, The University of Maryland, College Park, Md. 20740.*
- S-WA2.8 An Experimental Study on Solving Linear Programs, *A. RAVINDRAN, Purdue University, W. Lafayette, Ind. 47907.*
- S-WA2.9 A Revised Simplex Method for Quadratic Programming, *MICHAEL RUSIN, Mobil R & D Corp., P.O. Box 1025, Princeton, N.J. 08540.*
- S-WA2.10 Nonlinear Programming Solutions with Complex Variables, *DANIEL TABAK, Wolf Research and Development Corp., Riverdale, Md. 20840.*
- S-WA2.11 The Solution of Travelling Salesman Problems by Heuristic Algorithms, *ROBERT W. L. THOMAS, Wolf Research and Development Corp., Riverdale, Md. 20840.*

WEDNESDAY AM, APRIL 22

International Ballroom Center

11:30 – 12:30
SESSION: R-WA6 Plenary II

Speaker: To be announced

WEDNESDAY PM, APRIL 22

International Ballroom Center

Session: R-WP1 2:00 – 4:30

OR and The City – III
The New York City Story

Chairman: E. S. SAVAS

Deputy City Administrator, 250 Broadway, New York, N.Y. 10007

- R-WP1.1 Housing. Improving the Housing Code Enforcement Program, *STEPHEN R. ROSENTHAL, Housing and Development Administration, 100 Gold St., New York, N.Y. 10007.*
- R-WP1.2 Fire. Dispatching, Deployment and Relocation of Fire Engines, *ARTHUR J. SWERSEY, New York City RAND Institute, 545 Madison, Ave., New York, N.Y. 10022.*
- R-WP1.3 Police. A Simulation Model for Spatially Distributed Urban Service Systems, *RICHARD C. LARSON, MIT, Cambridge, Mass.*
- R-WP1.4 Other. A Selected Sampling of New York's OR Studies, *E. S. SAVAS, 250 Broadway, New York, N.Y. 10007.*

WEDNESDAY PM, APRIL 22

Georgetown East

Session: R-WP2 2:00 – 4:30

OR and The Hidden Problems of Education

(Sponsored by the Washington Operations Research Council)

Chairman: WALLACE M. COHEN

OPPE, U.S. Office of Education, 400 Maryland Ave., SW, Washington, D.C.

- R-WP2.1 Family Social Background and Process Factors Involved in the Development of Student Achievement and Motivation, *GEORGE W. MAYESKE, U.S. Office of Education, 400 Maryland Ave., SW, Washington, D.C. 20202.*
- R-WP2.2 Assessing the Side Effects of Educational Programs, *ALBERT E. BEATON, Educational Testing Service, Princeton, N.J. 08540.*
- R-WP2.3 Hidden Costs of Education: What Should Public Policy Be? *DENNIS J. DUGAN, Department of Economics, Notre Dame University, Notre Dame, Ind. 46556.*
- R-WP2.4 The Demand for Higher Education in an Urban Area, *ARTHUR J. CORAZZINI, Tufts University, Medford, Mass. 02155,*

WEDNESDAY PM, APRIL 22

Georgetown West

Session: R-WP3 2:00 – 4:30

Health Applications Contributed Session

(Sponsored by the Health Applications Section)

Chairman: JOHN P. YOUNG

The Johns Hopkins University, Baltimore, Md. 21218

- R-WP3.1 Impact of Reduced Physician Time Per Patient on Cost-Benefits of Multiphasic Health Screening, *HARRY E. EMLET, JR., Analytical Services, Inc., 5613 Leesburg Pike, Falls Church, Va. 22041.*

- R-WP3.2 A Systems Approach to Hospital Design, ~~TUNG AU~~ and ERNEST W. PARTI, Carnegie-Mellon University, Pittsburgh, Pa. 15213.
- R-WP3.3 A Stochastic Model for the Optimal Control of Epidemics and Pest Populations, DAVID L. JAQUETTE, Univ. of Southern California, Los Angeles, Calif. 90007.
- R-WP3.4 The Simulated Health Service Node, JOHN H. MOSS, Center for Environment and Man, 250 Constitution Plaza, Hartford, Conn. 06103.
- R-WP3.5 Performance Indices for Community Health Programs, JAMES E. MILLER, U.S. Public Health Service, P.O. Box 11340, Tucson, Ariz. 87506.
- R-WP3.6 Hospital Blood Bank Whole Blood Inventory Control, JOHN B. JENNINGS, M.I.T., Cambridge, Mass. 02139.
- R-WP3.7 A Generic Model for the Description and Evaluation of Acute and Chronic Disease Programs, JAMES MILLER, J. L. SANDERS, RONALD CHORBA, Univ. of Arizona, Tucson, Ariz. 85721.
- R-WP3.8 A Health Delivery System Simulator, WILLIAM HARDING, LANNY MULLENS, ROBERT L. BAKER, Univ. of Arizona, Tucson, Ariz. 85721.

WEDNESDAY PM, APRIL 22

Military

Session: R-WP4 2:00 – 4:30
Military Applications Contributed Session
 (Sponsored by the Military Applications Section)

Chairman. ROBERT R. HARE
Department of Mathematics, North Dakota State University, Fargo, N.D.

- R-WP4.1 Interfacing Field Medical Simulations, DONALD J. BOWES, JR., USACDC, Medical Service Agency, Fort Sam Houston, Texas 78234.
- R-WP4.2 Carriers and Land-based Aircraft in ASW, Mr. ROBERT MC QUIE, The John D. Kettelle Corp., 1701 N. Fort Myer Drive, Arlington, Va. 22209.
- R-WP4.3 Evaluation of Multi-Mode System Effectiveness, D. W. CHRISTENSEN, D. TERRIS, North American Rockwell Corp., 3370 Miraloma Ave., Anaheim, Calif. 92803.
- R-WP4.4 A Game Theoretic Model For Allocating Aerial Interdiction Effort, GERALD R. MC NICKOLS, HQ USAF, Operations Analysis, AFGOA, Washington, D.C. 20330.
- R-WP4.5 Mathematical Programming: A Military Production Planning, FREDERICK C. WESTON, JR. Colorado State University, Ft. Collins, Colo.
- R-WP4.6 Computerized Selection of Aircraft Spares Inventories, S. C. MOORE, R. D. GILBERT, R. W. MC MICHAEL, W. M. FAUCETT, General Dynamics, Fort Worth, Texas.

WEDNESDAY PM, APRIL 22

Jefferson Room

Session S-WP1 2:00 - 3:15
OR and Technology

Chairman. B. GORDON SMITH
GEOMET, Inc., Rockville, Md.

- S-WP1.1 Projection of Technological I/O Coefficients, ARTHUR CAROL, ISRAEL PRESSMAN, Polytechnic Institute of Brooklyn, Dept. of OR and SA, Brooklyn, N.Y. 11201.
- S-WP1.2 Computation of Optimum Planar and Location Strategies for a Stationary Spare Satellite, T. S. CHIDAMBARAM, Comsat, 950 L'Enfant Plaza South, Washington, D.C. 20024.
- S-WP1.3 The Application of Tactical Decision Models to Inventory Management, R. I. GREENBERG, RCA Defense Electronic Products, 558 Federal Street, Camden, N.J. 08103.
- S-WP1.4 Control Model Simulation, EDWIN HULLANDER, Iowa State University, Dept. of Industrial Engineering, Ames, Iowa, 50010.
- S-WP1.5 Optimum Nuclear Fuel Cycles for an Advanced Converter Reactor-Decision Making Under Uncertainty, J. C. SCARBOROUGH, NUS Corporation, 2351 Research Blvd., Rockville, Md. 20850.
- S-WP1.6 Computer Simulation of Rotomailer Operations, H. TRAMPOSCH, Pitney-Bowes Inc., Stamford, Conn. 06904.
- S-WP1.7 Engineering Design Optimization Under Risk, JOEL WEISMAN, University of Cincinnati, Cincinnati, Ohio, A. G. HOLZMAN, University of Pittsburgh, School of Engineering, Pittsburgh, Pa. 15213.
- S-WP1.8 Stationary (s,S) Policies for a Finite Horizon, ALAN C. WHEELER, Washington University, Dept. of Applied Mathematics and Computer Science, St. Louis, Mo. 63130.
- S-WP1.9 Probabilistic Evaluation of Helicopter Lift Capability, D. G. Brown, E. LEVY, D. R. LIMAYE, R. A. OREN, The Boeing Company, Vertol Division, P.O. Box 16858, Philadelphia, Pa. 19142.
- S-WP1.10 Patterns and Determinants of Common Stock Price Volatility, EDWARD I. ALTMAN, ROBERT A. SCHWARTZ, Graduate School of Business Administration, New York University, 100 Trinity Place, New York, N.Y. 10006.

R-MA1.1. Participation in Illegitimate Activities—An Economic Approach ISAAC EHRLICH.

In this study an attempt is made to investigate the effectiveness of law enforcement and other related issues by setting up an economic model of participation in illegitimate activities and testing it against the empirical evidence. It is proposed that illegitimate behavior is a result of choice under the uncertainty of punishment, and that those pursuing illegal activities generally respond to the relative opportunities, i.e., costs and gains available to them in legitimate and illegitimate endeavors. This framework is developed to identify some measurable factors which determine individuals' decisions to participate in a criminal activity and the extent of such participation at any given period. Several implications of the analysis are tested in the empirical investigation, which employs a cross-state regression analysis of specific offenses reported by the F.B.I. and of specific racial groups in the U.S. in 1960, 1950 and 1940. Ordinary least squares and simultaneous equation estimation methods are used to estimate "supply functions" of offenses.

R-MA1.2 Some Resource Allocation Problems in Law Enforcement. ALBERT M. BOTTOMS.

This paper addresses some of the social and operational factors considered by the Police Administrator in allocating police patrol resources among geographical sectors. The allocation and effectiveness implications of alternative allocation criteria and constants are developed and compared. Methods for taking community preferences and demands into account are demonstrated for the case of the City of Chicago.

R-MA1.3 Reducing Crime in Apartment Dwellings. MICHAEL LIECHENSTEIN.

This research, done under the auspices of Mayor Lindsay's Criminal Justice Coordinating Council, examined techniques for improving security in New York City Housing Authority buildings. The crime patterns in the housing projects were analyzed first to determine the major threats against security. Next, a theoretical analysis was undertaken to develop criteria for judging the effectiveness and operational suitability of arbitrary security systems. This served as a basis for grading the effectiveness of fifteen security alternatives that were synthesized from knowledge gained on criminality, security technology, and characteristics of the protected environment. These performance scores were finally coupled with cost estimates to ascertain the most cost-effective candidates for possible implementation.

R-MA1.4. Planning Emergency Ambulance Service in an Urban Environment—An Analytical Approach. KEITH A. STEVENSON

By making simplifying assumptions about the spatial distribution of demands for emergency ambulance service, models are developed to indicate the deployment of vehicles and their number in order to provide an acceptable "level of service." The "level of service" consists of the response time and the probability of encountering delays, and is associated with the number of vehicles in the service and their location. Relating costs to the level of service provides a methodology for the evaluation of alternative systems.

R-MA2.1. Evaluating Social Action Programs. JOHN W. EVANS.

Relatively little hard evidence exists on how successful the Government has been in its efforts to alleviate social and economic problems by means of large scale education, manpower, and welfare programs. This paper analyzes some of the organizational conditions within domestic government agencies which determine how successful they can be in evaluating the effectiveness of their programs. It traces the experience of the Office

of Economic Opportunity in attempting to evaluate its programs and outlines some of the changes which need to be made if evaluation is to become an integral part of the Federal decision making and resource allocation process.

R-MA2.2 The Westinghouse/Ohio University Evaluation of Head-Start. VICTOR G. CICIRELLI.

The study inquired whether children now in the first, second, or third grade who had Head Start experience, either summer or full year, differed significantly in their cognitive and affective development from comparable children now in these grades who did not participate? Approximately 2000 "graduates" of 104 Head Start programs were compared to 2000 control children on standardized achievement and language development tests, and on staff-constructed measures of self concept, achievement motivation and attitudes. Results indicated that summer programs ineffective, full year programs marginally effective; recommendations included phasing out summer programs and improving effectiveness of full year programs.

R-MA2.3. Evaluating Community Action Programs: The Measurement and Comparison of "Hometown Fights". JAMES J. VANECKO.

The Community Action Program was declared by the Office of Economic Opportunity to be "a hometown fight." The difficult question such a declaration poses for evaluation research is how to develop measures of effectiveness which are both relevant and comparable across a sample of "hometowns." This paper reports on an evaluation study of the Community Action Program goal of "institutional change" in 100 urban CAP's. The solution to the measurement problem is found in linking small scale concrete changes with a developmental model of CAP's ability to diffuse these. CAP's oriented toward community organization are more effective than service oriented CAP's.

R-MA2.4. Evaluating Social Action Programs. The Medical Program. VERGIL N. SLEE.

The medical audit program is offered by the Commission on Professional and Hospital Activities to assist hospitals in monitoring their medical practice. For each patient discharged from the 1300 participating hospitals, a medical record abstract is sent to the Commission where the information is recorded on magnetic tape and a computer-produced array of displays of the individual hospital's practice is produced. In addition, the hospital is compared with other hospitals as to clinical practices and experiences. Computer monitoring of the data and exception reporting are used. Schools are conducted for instruction of physicians, administrators, and medical record personnel on how to monitor medical practice. The system and some of its problems and implication will be discussed.

R-MA3.1. Intercity Transportation Effectiveness Model. JOHN BASILE, WILLIAM A. JESSIMAN, DONALD E. WARD and DANIEL P. MAXFIELD.

The Intercity Transportation Effectiveness Model was developed as a tool to approximate the mix of aircraft, routes, schedules, and terminal facilities that would satisfy intercity air carrier passenger and cargo demand at minimum social (time) and economic cost. The model is structured as a set of integrated computer modules, each of which can be exercised individually: Passenger and Cargo Demand provide demand forecasts; Route Selection screens all possible routes and narrows choice of routes to a manageable number for analysis; Daily Traffic Assignment assigns passengers, cargo and aircraft to routes; Initial Timetable and Fleet Reduction produce complete timetables and aircraft itineraries. The Daily Traffic Assignment Module is a decomposed linear program in which a unique method is used to solve the subproblem in greatly reduced running time.

R-MA3.2. Practical Algorithms for Scheduling Ground Transportation Systems. PATSY B. SAUNDERS.

A comparison is made among several algorithms for constructing timetables for the operation of fixed schedule ground transportation systems. Emphasis is placed on those methods for which data are readily obtainable. Compatibility with related models (such as demand models) is also discussed.

R-MA3.3. Fleet Size Planning for Unbalanced Stochastic Demands. E. FARNSWORTH BISBEE.

The general problem regarding fleet size planning includes the determination of equipment availability requirements at the nodes of a network to service transportation markets over a route structure where projected demand defined on node pairs is directionally unbalanced. For the resulting asymmetric demand matrix, a feasible assignment of departure times at each node constitutes a schedule whose value depends on expected load factors, aggregate delay, operating cost inherent to the schedule, and the investment cost of the required fleet. A method is presented of generating departure times and the capacity dispatched at each which recognizes the stochastic nature of demand and seeks "best" average capacity allocations weighted against demand equilibrium conditions and service level.

R-MA3.4. Behavioral Considerations in Modal Split Analysis. LESTER A. HOEL and MICHAEL J. DEMETSKY.

Travel decisions are viewed by considering the individual as the basic unit of travel. The variables selected for this model are those related to the trip (i.e., trip purpose, trip length, etc.); the trip maker (i.e., income, household size, etc.); and the transportation system (i.e., travel time, cost, convenience, etc.). A multiple regression equation is formulated and tested. The concept of a model preference rating is introduced which renders a numerical rating in agreement with premises of additive utility theory for each mode available for a given trip, and a modal preference function is presented. The model provides the conditional probability that a specific trip will be made on a given mode. It is calibrated using actual trip information and a numerical rating of modal characteristics.

R-MA3.5. Mathematical Models to Predict Travel Demand. RICHARD KU.

The formulation of a mathematical model to predict *inter-urban* passenger travel demand is discussed. Demographic and socio-economic variables, and variables which measure transportation characteristics (such as cost of a trip or trip time) are used in the prediction of demand patterns for both future modes of travel and existing modes. A set of criteria which such a model should satisfy is used as the basis for an axiomatic approach to its formulation. These criteria are based on mathematical, economic and pragmatic considerations within the context of the model application. Estimation of model parameters and their interpretations are also discussed.

S-MA1.1. An Activity Information System for the Control of Faculty Workload in a Dynamic University Environment. W. J. FABRYCKY.

This paper describes the structure and dynamic characteristics of a computerized information system which accepts n weighted categories of faculty activity at discrete points in time. Output summaries are made available to m levels of academic administrators so that the workload of academic units may be compared on a relative basis. Control is effected by the allocation and reallocation of faculty positions to academic units to maintain a workload balance. The behavior of the system under changes in activity demand, mix, and weight is illustrated for a hypothetical university.

S-MA1.2. School Bus Routing Via Computers. PAUL L. KINGSTON.

This paper describes the experiences of a citizens committee, chartered to study transportation costs of a suburban central school district in upper New York State. Two operations research techniques are used. First linear programming is used to assign students to schools in order to minimize transportation distances. Then the truck dispatching technique is used which tends to optimize the bus routes of the assigned students. The paper begins with background of the school transportation system and of the citizens committee. It then proceeds with a case study of the problems encountered in data collection, language barriers of the committee, simulation of alternatives, and implementation. The paper concludes with recommendations necessary for successful implementation of computers to school bus routing problems.

S-MA1.3. Bus Routing in a Multi-School System. RITA M. NEWTON and WARREN H. THOMAS.

A practical computer based method was developed for generating a set of bus routes, satisfying bus capacity and student riding time constraints, which specifies school-to-school sequencing of each bus and the stop-to-stop route to be followed in traveling to every school. Optimization is with respect to minimizing not only the total bus travel time (including running empty) for a school but also the number of routes required to service all the stops associated with the school. An efficient routing system involving 6 possible bus route origins and 96 stops was developed in 61 seconds on CDC 6400 computer for a school of the Williamsville New York Central School District.

S-MA1.4. A Mathematical Model for Measurement and Control of Classroom Achievement. PAUL D. PINSKY.

Before mathematical control theory can be applied to classroom achievement a measurement system must be developed that will provide the information required as inputs in presently available control models. The measurement model discussed considers a course defined in terms of performance criteria, and generates estimates of student performance at a preinstruction, post instruction, and retention level for each of the performance criteria. This model is operational on an experimental basis in various cities throughout the country. Extensive computer programs are being used to feed back information on a weekly basis concerning curriculum development, group and individual performance. Algorithms have been developed to allow the computer to dynamically select actual test items to be presented to each student throughout the year. The criterion for selection is the maximization of the value of information obtained in terms of curriculum, group, and individual student data.

S-MA1.5 A Generalized University Model. TIMOTHY W. RUEFLI.

This paper reports the progress of the Project Generalized University Model at the University of Texas in the application of management science techniques and architectural design to institutions of higher education. Various simulation and decision models are presented, and a particular structure for a generalized university model is developed in detail. The final section of the paper discusses the implications of the model in a framework of planning for higher education at the regional, state, or national levels.

S-MA1.6. A Class Scheduling Model. MILTON E. F. SCHOEMAN and GORA BHAUMIK.

As the quantity of students, courses, faculty members and physical facilities in colleges and universities increase, the problems associated with coordinating and scheduling them become more massive and complex. This paper reports on a fairly general, comprehensive mathematical model for class scheduling which has been designed for implementation on computers. This model differs from previous attempts in its explicit utilization of student preferences as well as faculty preferences for class meeting times. Also included are considerations of location, multiple sectioning, class size, needs for special facilities, and the results from past scheduling. Finally, a computationally efficient algorithm for use with the model is developed.

S-MA1.7. RMC's Automated School Cost Model—Developed For and Applied in Planning the New Community of Fort Lincoln. DONALD STROPE.

An automated model was developed by RMC for the Washington, D. C. Public Schools as an aid in designing the school system of the new community of Fort Lincoln. It computes the costs of education programs differentiated from each other by a wide range of features such as student-teacher ratios, curriculum, equipment, and staffing. The ease of manipulating these key variables and of obtaining the total resource implications of changes in them through the model permits planners and decision makers to see at once the resource impacts of specific program changes and thus provides flexible experimentation on paper in a cost-benefit and program-budgeting framework.

S-MA1.8. The Use of a Totally User-Oriented Self-Teaching, Interactive Computer Program for Mathematical Problem Solving. MARTIN I. TAFT.

A computational and instructional software package known as DES-COMP III provides on-line mathematical problem-solving capabilities without the necessity of program-writing or compiling. DES-COMP III performs all types of arithmetic computations; stores values for later recall and use in computations; and computes the values of any function. The program automatically generates tables and multi-variable graphs of input data or computed values. Whenever the user asks for help, the computer teaches him what he needs to know in order to proceed. Various applications in OR, business, and education are described.

S-MA1.9. Micro Level Resource Allocation Models for Universities. ISMAIL B. TURKSEN and ALBERT G. HOLZMAN.

Mathematical programming models of micro level activity analysis for universities are constructed. The micro level activity analysis is related to the departmental level in the organizational structure of a university. Formulations are general and can be applied to other micro level decisions. Three basic sets of activities are recognized: teaching, research, and other activities. Resources are assumed to be known in terms of hourly availabilities. They are not converted into financial and budgetary concepts. The mathematical programming formulations are in linear and quadratic integer forms for current planning models. The formulations are extended to dynamic programming for finite short range planning purposes. It is assumed that demands are known in the form of forecasts.

S-MA1.10. A Micro Level Forecasting Model of Student Enrollment. ISMAIL B. TURKSEN and LEO KATZ.

Theoretical concepts are developed for a micro level forecasting model of student enrollments. The states of: course completion, eligibility, and enrollment are defined and utilized in the development of the model. The stochastic behavior is defined as a function of the eligibility state and a parameter set of probabilities. Exponential and Bayesian smoothing techniques are applied to the elements of the parameter set of probabilities. Pass and fail probabilities are related to a characteristic of student population given for a particular course. Expectation and prediction are distinguished within the context of this forecasting model. Expectation is applicable to the current planning forecasts, whereas predictions are developed for finite short range planning forecasts. The model assumes the availability of a management information system.

S-MA1.11. A Simulation Model System for Short and Long Range Planning and Budgeting in Health Sciences Education. R. WILSON, J. R. WALTER and S. JONES.

The multiple and often conflicting objectives in health care, education and research make planning and decision-making in health sciences education extremely complex and confusing. Unwise or ill-informed decisions are becoming too costly to the public for decision-makers to function without adequate information, and objective examination of health sciences education alternatives. The paper will describe an interdisciplinary planning approach and a computer-based system of simulation models being used to assist short and long range planning and budgeting in the University of Toronto Health Sciences faculties and schools and associated teaching hospitals and health care centres. The model system has sufficient breadth to examine the many different disciplines in health education (e. g. Medicine, Nursing, Dentistry, Hospital Administration, Public Health, etc.), and sufficient flexibility to be applicable at any existing or proposed health sciences education centre.

S-MA2.1. An Investigation of an Adaptive Programming Technique for the Optimization of Urban Highway Planning Decisions. JOHN W. DICKEY and MARTIN P. AZOLA

The EMPIRIC Programming Technique was developed to provide the urban planner with a workable tool with which he can determine the highway improvements necessary for desirable land use development in the future. A six zone example problem is posed for

the testing of the EMPIRIC Programming Technique. Three forecast periods, each ten years in duration are made successively, and the results are analyzed with respect to accuracy, adaptability and validity. The EMPIRIC Programming Technique is shown to be an accurate and adaptive planning tool. Changes over a 30 year period in desirable land use on the order of .103 per cent up from the initial land use pattern are found. However, some sensitivity to the accuracy of input data has been noted.

S-MA2.2 A Climatological Model for Forecasting the Demand for Police Service. NELSON B. HELLER and ROBERT E. MARKLAND.

The rate of citizen calls for police service exhibits marked seasonal fluctuations, generally reaching a peak during the summer months and slacking off to a low point in mid-winter. Data from St. Louis, Chicago, and Detroit indicates a high correlation between the number of calls per week and meteorological variables such as average temperature and hours of daylight. Simple regression models using the weekly norms for the weather variables are used to forecast the weekly demand for police service in each of the three cities. Since the weather data is easily obtained from the local Weather Bureau, and only a single year of police data is needed to estimate the coefficients, police planners may find such climatological models handy for scheduling patrol deployments and officers' vacations.

S-MA2.3. Preferences for Response Times to Fires. RALPH L. KEENEY.

In most urban fire departments, there is a standard response to a fire alarm involving specified numbers of engines and ladders. Associated with a response is the response time of each piece of equipment. For evaluating dispatching strategies, etc., it would be useful to have a utility function for the response times of these engines and ladders. In this paper, we develop some theory which is relevant for assessing such a utility function. Specifically, we make reasonable assumptions about the preferences for fire response times, derive the restrictions on the structure of the utility function imposed by these assumptions and indicate the information necessary to specify the resulting utility function. Preliminary application of the theoretical results are reported.

S-MA2.4. Optimal Transfer Facility Location for Solid Waste Collection. DAVID H. MARKS and JON C. LIEBMAN.

Transfer facilities, where small special purpose collection vehicles may discharge their loads to large special purpose transport vehicles, have been suggested as a means for lowering the cost of solid waste collection. An optimal algorithm is presented for locating such facilities which minimizes the cost of facilities and transportation subject to constraints on demands. Results from a recent study in Baltimore indicate the feasibility of such transfer stations and the sensitivity of optimal location to changes in system parameters, in work rules, and in political and economic constraints.

S-MA2.5. A Mathematical Programming Model for Water Renovation and Blending for Coastal Cities. SHISHIR K. MUKHERJEE.

Most cities are facing an ever increasing demand for fresh water due to population and industrial growth. This paper presents a mathematical programming model for blending water from various sources—treated fresh water, desalinated sea water and renovated waste water—to supply future demands for multiple water use in coastal cities at minimum cost. Water quality requirements of municipal, industrial, agricultural and recreational use are specified as multi-component quality standards and the corresponding demands are known. Costs of water of given quality from different sources and by desalination and renovation are assumed known. The model develops optimum blend of water for various uses and minimizes the total costs.

S-MA2.6. Mathematical Programming Applications to Water Quality Planning for the Boston Harbor Region. JOHN C. SCHAAKE, JR.

A study is being made at the M.I.T. Urban Systems Laboratory of alternative schemes to improve the water quality of the Boston Harbor. As part of this study, several

computer models have been developed. One of these is a mathematical programming model which is being used to find optimal investment configurations that meet specified water quality criteria. This model requires information about pollution transport mechanisms, so two other computer models have also been constructed on the basis of the fundamental principles which govern both the tidal currents and the pollution transport. Using these models, it is possible to simulate conditions as they exist now or to simulate other conditions that would exist if changes were made in the physical configuration of the harbor or in the pollutant loadings.

S-MA2.7. Cost-Effectiveness Analysis of Refuse Collection Operations. TOM SCHAFFER.

This study describes an application of operations research techniques to refuse collection departments. In the study, a refuse collection department is considered to be a system of men (refuse collectors) and machines (refuse trucks) interacting with (collecting refuse from) an environment (municipality). Two sets of mathematical models are developed; one set describes the costs associated with the complete system and with each of its operating parts; the second set describes the work obtainable for a given resource (cost)input. The two sets of models are used together to calculate the combination of operating conditions that will minimize total system operating costs. Emphasis is placed on the practical use of the models, including a data collection plan to get unbiased values for model parameters.

S-MA2.8. A Quantitative Approach to Urban Problem Analysis. ROBERT E. SHANNON and RICHARD M. WYSKIDA.

Precise, unambiguous definitions of the Socio-Economic problems of Urban areas are required before solutions can be found and results evaluated. This paper reports the approach utilized and the results obtained by an interdisciplinary operations research team in defining and analyzing the problems of the Model Cities Neighborhoods in Huntsville, Alabama. A stratified random sample was collected from the twenty sub-neighborhoods to identify the problems as perceived by the residents, as well as to establish a socio-economic profile of each neighborhood.

S-MA2.9. A Systems Approach to Municipal Water Quality Management. C. S. SHIH, W. L. MEIER, JR., and D. S. MILLER.

Cities adjacent to rivers usually rely on them both as sources for water supply and as avenues for the disposal of wastes. The stream serves as a link creating a water quality interdependence among all cities using the water course as water supply or waste sink. Present-day water and waste treatment design practice considers each municipality as independent of others and ignores the dependence between water and waste treatment costs. This paper presents optimization techniques based on dynamic programming which evaluate the trade-off between waste treatment costs at upstream cities and water treatment costs at downstream cities.

S-MA2.10. Coronary Emergency Rescue Services Treated as a Queuing System. B. GORDON SMITH.

A flexible methodology has been developed to permit any community to assess the cost-effectiveness of coronary emergency rescue services (C.E.R.S.). The need for this is evident from the number of communities acquiring this expensive service without any real measure of its ability to save the lives of heart attack victims. Simulation and analytical queuing techniques are used to compare C.E.R.S. and conventional rescue services on the basis of the time taken to provide sophisticated therapy. The time saved with a C.E.R.S. is then converted to an approximate saving of lives in a given community. The methodology can be extended to permit evaluation of other emergency rescue services.

S-MA2.11. The Emergency Medical Service System Model (EMSSII). ABIGAIL B. WEMPLE and ROBERT R. HARE.

EMSSII simulates the overall operation of emergency medical service systems from the time patients are generated until they receive treatment at an emergency medical

facility and are then either released or moved to a hospital. The model considers such systems functions as detection, communication, patient acquisition, transport, and treatment. It can be used to evaluate as well as plan emergency medical service systems and to provide detailed analyses of the staffing, organization and structure, and transportation and communication requirements necessary for near-optimum system performance. Inputs are used to describe system facilities and organization, and to specify operating policies.

R-MP2.1. Cost-Effectiveness Analysis for Emergency Coronary Care Alternatives. J. R. WARD, W. T. TOWLES and B. G. SMITH.

Recent studies have indicated that more than sixty percent of acute coronary victims die before or soon after hospitalization. Many proposals for providing timely and more effective pre-hospital care are now being investigated. Under contract to the National Heart Institute, the authors reviewed current efforts and developed a general framework for specification and evaluation of various alternatives. First, current data on the characteristics of heart attack victims and emergency care systems were analyzed to determine implications for early care. Next, measures of system performance were defined in terms of timeliness and level of care and an analytical model developed. To complete the framework, a procedure for identifying alternative systems in terms of combinations of their components was outlined, along with guidelines for estimating startup and operating costs. The overall methodology was then utilized to evaluate three schemes of current interest: Mobile coronary care units, a public education program, and a screening program. Results were commensurate with other, independent evaluations and proved adequate to guide program planning.

R-MP2.2. The Transportation Needs of the Rural Poor. JON BURKHARDT and CHARLES EBY.

This study analyzes the transportation needs of the rural poor by conducting a cost-benefit analysis of a rural transportation demonstration program operated by the Raleigh County Community Action Association, in West Virginia. Cost-benefit analyses are conducted for several hypothetical alternatives to the actual demonstration program, and the relative merits of each are discussed. The alternatives include both other kinds of transportation systems and non-transportation systems which affect the need for transportation. Since the demonstration program was conducted in a specific and perhaps atypical geographic region, the applicability of our results to other parts of the country is discussed. Two aspects of the cost-benefit methodology are unusual. First, multiplier effects are considered and the cost-benefit impacts are followed through several rounds of economic activity. Second, the analysis attempts to show redistribution effects as well as aggregate, economic efficiency effects. In addition to the cost-benefit approach, an attempt was made to establish some absolute level of transportation "needed" by the rural poor.

R-MP2.3. Cost-Effectiveness Analysis of Civil Engineering Systems: New York City's Primary Water Supply as an Example. RICHARD DE NEUFVILLE.

A methodology for cost-effectiveness studies of civil engineering systems is proposed and illustrated by an example of its application. The approach tries to bridge the dichotomy of objectives which often exists between the policy levels of government and the engineering agencies, and which leads to frequent impasses for implementation. The process first attempts to broaden the traditional terms of reference for the design of public works, which are usually governed by engineering standards only tenuously related to the multiple objectives of a facility. Second, a procedure is suggested for the generation of alternative configurations of the system and its components. Finally, a means is presented for the exploration of alternative time-phased strategies of development.

R-MP2.4. Planning R&D for Maximum Net Payback. ROBERT L. HAMSON.

Life cost and effectiveness equations uniquely identify the absolute optimum RDT&E funding and topics supporting an objective. The optimum R&D program always exists and is found by tradeoffs among all phases (R&D, production, and operation) and all subsystems. Comprehensive criteria uniquely intergrate all fundamental parameters and

- unambiguously select weightings which are continuously varied at the instantaneous operating point. The equations help reduce R&D-planning data to the relevant cost and benefit inputs, evaluate ever present risk and errors, and expose significant R&D funding rules not previously obvious. Applications include military, environmental, education, medicine, transportation, business, etc.

R-MP2.5. Multi-Stage Manufacturing AIQL-AOQL Problem from Cost Effectiveness Point of View. SEDAT SAMI ERCAN.

This paper investigates the relationship between incoming quality limit, manufacturing process characteristics and the outgoing quality limit for a multi-stage manufacturing situation from cost effectiveness point of view. An optimal single sampling plan where inspection is by attribute is derived for this situation assuming average cost of replacement or repair of a defective unit and opportunity loss of a unit for single component product.

R-MP3.1. A Mathematical Programming Approach to Designing More Effective and Politically Acceptable School Finance Plans. JAMES BRUNO.

In most states attempts at increasing state grants to poor low local-ability school districts which would result in lower state grants to wealthy or high local-ability districts have met with repeated failure. In foundation-type state-support programs, basic aid and the minimum state mandated qualifying tax rate are both uniform. States therefore desiring to increase their grants to low local-ability districts or decrease the spread in fiscal per-pupil expenditures must either allocate more total state funds, eliminate basic aid (decrease their aid to high local-ability districts) or develop a variable minimum qualifying tax. This study will focus primary attention upon this latter option. Linear programming techniques were used to determine an optimal minimum qualifying tax rate for a group of districts in a foundation-type school finance program. The results obtained in this exploratory study, decrease in the spread of fiscal expenditures, increase in state grants to low local-ability districts with no increase in the total amount of state funds and no decrease in state grants to high local-ability districts, strongly suggests the use of this or similar approaches in designing more equitable and politically acceptable school finance schemes.

R-MP3.2. The Optimum Allocation of University Spaces. DUNCAN BAILEY, PAUL HAMEL-MAN and CHARLES SCHOTTA.

This paper develops and illustrates a model for securing the optimum allocation of student spaces among the various curricula in a broad range university, assuming a fixed total enrollment. The model pertains, in its present form, solely to a state-funded university since the object function which is maximized consists of the present value of the expected differential life-time stream of income (over that which would be earned by a high school graduate) less the present value of the total cost of the state and to the individual of producing the increment in human capital in the university. Joint costs of different departmental curricula are explicitly treated in the model. We are able to evaluate the optimum mix of students among the various university curricula when the relationship between increased total state income and the cost of each distribution of students among curricula is considered. Thus, for educational decision-makers anxious to return the greatest dollar benefit to the taxpaying public, such a model will be useful in making internal resource allocation decisions among departments in the university.

R-MP3.3. A Model of the Funding Decision-Making Process. YING C. CHUANG.

During the past few years although a number of evaluation models have been developed, there are few adequate conceptions of funding decision-making process and their associated information requirements in Title I evaluation. Therefore, the major aim of this paper is to describe a model of the funding decision-making process which has been used in Title I Evaluation in the Philadelphia school system, and is being proposed for use in the New York City school system. Conceptualizations used here is being viewed as a way of reminding us to ask questions about the relative importance of various facets of the

problem concerned under the limited financial resources. The model of the funding decision-making process will be presented and illustrated with some implications in this paper.

R-MP3.4. A Computer Simulation Approach to Enrollment Projection in Higher Education. ALLEN BAISUCK and WILLIAM A. WALLACE.

The purpose of this paper is to report on the development and evaluation of a simulation model for the projection of enrollment in any system of higher education. A model of the movement of students through an educational system was designed and programmed for on-line usage by non-mathematically oriented planning personnel. The computer model offers the planner the opportunity to incorporate alternative sets of assumptions regarding the future by changing the original set of projections. These assumptions are formulated in numbers and proportions of students and the distribution of these students throughout the educational system. Evaluation of the model was conducted in depth at a private, technological university, Rensselaer Polytechnic Institute, in a public city university, a community college, and a statewide planning activity.

R-MP4.1. Manpower Planning and Project Progress Measurement. CHARLES E. JONES and ROBERT H. CULHAN.

Projections of scientific manpower (and facilities) requirements to support the company's long-range product development programs must be made many months in advance so that recruiting and organization structuring will be complete at the time when R&D efforts should be expended. Systems for R&D project planning and progress monitoring help R&D management make decisions to improve the effectiveness of the R&D process. Experiences in the development and application of manpower planning models and project planning and monitoring systems in the company's R&D division are described, with special emphasis on the successful functioning of an R&D management project team consisting of university faculty and graduate students, the company's OR section and the research director and his managers in the company's central research center.

R-MP4.2. Evaluation of New Product Facilities Under Best Price. Marketing Effort, and Expansion Phasing Systems. M. KLEIN.

In the preliminary evaluation of the profitability prospects of a new product we usually forecast the demand curve over the product life cycle and find the net present value. A subsequent more detailed study might embrace extensive simulation of consumer behavior under the impact of advertising and other factors. However, even the preliminary evaluation is deficient when both demand and plant size are arbitrarily set. This paper proposes a simple exponential functionality of demand with price, effort, and time as well as of cost and capital with plant size. While costly extensive optimization methods may not be indicated for preliminary evaluations, some trial and steepest ascent procedures may lead to an adequate approach to optimum. An example illustrates the procedure.

R-MP4.3. Planning and Control Techniques for Applied Research. WILLIAM E. SOUDER.

Although a number of techniques and models for planning and controlling research have been proposed, there are few reports of their actual use. In 1963, Monsanto began a study to develop and implement a total planning and control system for applied research. A two-dimensional dynamic programming planning model and the cost-progress variance control model were developed, pilot studied and implemented. The system has been used in a number of applications and the results were beneficial. However, studies indicate that certain types of data are critical to the successful use of such systems. And recent research indicates that if the wrong type of planning model is used in such systems, it can lead to erroneous decisions. The desirable features and characteristics of improved planning and control systems for research have been developed from this research.

R-MP4.4. Exploratory Development Project Evaluation. BURTON V DEAN and LEWIS A. ROEPCKE.

This paper describes a method for evaluating long range exploratory development projects. Relevant factors are identified and anonymous judgments are made by members of a selected panel. Evaluations of projects with respect to each factor are performed using several rounds and justifications of extreme positions. Overall subjective project evaluations are also obtained using the same method. These project values are used to determine the important factors and associated weights. Results-to-date indicate that (1) panel members research significant agreements on factors, weights, and values, (2) a small number of factors are critical in determining a project's value, and (3) a linear scoring model is useful in evaluating exploratory development projects.

R-MP5.1. Measurement and Modeling of the ARPA Computer Network. L. KLEINROCK

The Advanced Research Projects Agency (ARPA) of the Department of Defense has begun the implementation of an experimental nation-wide computer network. The network measurement center at UCLA has undertaken the task of measuring the behavior of this network, and also the task of constructing and analyzing appropriate models of this system. Early results on this measurement and modeling effort are available, and results are presented regarding the agreement between these two.

R-MP5.2. Application of Flow Methods to Power Distribution. S. D. CHAUBEY and I. T. FRISCH.

A standard problem arising in the utilization of power distribution systems is the determination of power flow and input and load voltages for specified power and voltage magnitude input conditions. The size of the networks involved makes matrix inversion techniques difficult. Therefore, we develop an alternate approach by determining two resistive networks which model the original network. One resistive network is used to determine real power flow and the other resistive network is used to determine reactive power flow. The solution to each resistive network can be obtained from a quadratic programming problem which can be solved by flow techniques. The interaction between the solutions to the two networks is determined and the process is iterated until a solution for the original problem is obtained within the desired limits of accuracy.

R-MP5.3. Survivable Networks With Priorities. W. CHOU.

Many network survivability problems are studied by using network connectivity as the measure of survivability. That is, survivability is measured by the number of nodes or branches that must be removed in order to disconnect the network. By so doing, all the nodes are treated equally and the design with such a criterion often results in a regular graph. Alternatively, for each pair of nodes in the network, survivability can be measured by the number of nodes that must be removed to place the two nodes into two unconnected subgraphs. The problem presented here is to construct a graph with minimum number of branches such that the number of nodes in any node cut set separating [the i th and the j th] two nodes is at least equal to a prescribed non-negative integer $[r_{ij}]$, for $i, j = 1, 2, \dots, n$, and for $i, j \neq$

R-MP5.4. One Terminal TELPAK Optimization. B. ROTHFARB and M. GOLDSTEIN.

To lease long distance telecommunications facilities, the lessee submits for billing purposes a configuration of individual channels and bulk units of channels called TELPAKS, which implement his requirements. The bulk rates charges for TELPAK's result in the cost of channels between a give pair of points being a piecewise linear function of the number of channels. This function is neither concave nor convex. We give a characterization of an optimal solution and present a method for obtaining a low cost configuration when all requirements are to a single point.

R-MA5.5. Optimal Design of Offshore Natural Gas Pipeline Systems. B. ROTHFARB, H. FRANK, K. STEIGLITZ, and D. J. KLEITMAN.

The exploitation of offshore natural gas involves several phases including production from reservoirs, separation of byproducts, and transportation to markets. The gas, which may originate as far as 100 miles from land, must be transported through pipelines to onshore delivery points. There it is processed and then transported to its markets. The cost of constructing underwater pipelines is a substantial part of the total cost of offshore natural gas. This paper develops techniques to solve the following problems: (1) Selection of pipe diameters in a specified pipeline network to minimize the sum of investment and operation costs; (2) selection of minimum cost network structures, given gas field location and flow requirements; (3) optimal expansion of existing pipeline networks to include newly discovered gas fields. The design techniques incorporate procedures for globally optimizing pipeline diameters for fixed tree structures and heuristic procedures for generating low cost structures.

S-MP1.1. Education for Operations Research in Urban and Regional Planning. HERMAN G. BERKMAN.

Recent changes in the scope of the field of urban planning have been recognized by the American Institute of Planners. Training programs for educating planning professionals must reflect these changed conditions. Among these new components is expansion of the field to cover planning for public service delivery systems as a necessary component to planning for the physical development of the community. Such a new charge causes severe problems of adjustment of university curricula insofar as programs for training urban planners is concerned. Training programs involving operations research in planning specifically, must deal with appropriate cases. For some years, the author of this paper has been attempting to cull operations research literature to derive examples of *what* must be taught within this revised context to planners as compared to administrators. The paper proposed will present the results of this investigation and will discuss ways in which operations research training for urban planning professionals can be accomplished under conditions of changing roles for urban planning personnel as they interface with the professional public administrator and consulting bodies to governments.

S-MP1.2. Sociological Goals and Curriculum Content in Education. C. J. HARRIS.

We are cautioned against applying operations research to urban problems without first carefully evaluating the input data and clearly defining goals. As an example, it has been shown that mental violence, such as the passing on of distorted sociological information, has been permitted in the institutionalized national educational program. The Consistency Matrix and Decision Tree were suggested as operations research tools useful in helping to rectify this situation. A new mathematical technique, the Sociological Coordinate Value System (SCVS), and Probabilistic Information Processing Systems (PIP), are evaluated as to their applicability in further judging goals and the credibility of the content of the input data used in historical and sociological education courses.

S-MP1.3. Moon Shots Won't Stop Riots. DONALD E. HUNTER.

We are witnessing the beginning of a transition in national priorities from defense to domestic concerns. One result is an escalating trend toward applying "space age technology" to urban problems. The city government environment and decision-making calculus, however, are considerably different from either defense or space programs '67. The structure of state and local governments, type and intensity of local politics, degree to which mayors and councils really control their governments, funding levels, degree of rationality in decision, and levels of staff capability all make useful applications of OR methods and systems techniques quite limited. A few specific applications that hold promise for future successes are reviewed and evaluated.

S-MP1.4. The Quality of Urban Life in the United States — A Study of Urban Indicator Methodology and Presentation. MARTIN V. JONES and MICHAEL J. FLAX.

The 20 largest U.S. metropolitan areas are quantitatively compared with respect to

12 different facets of the "quality of urban life". For each of these 12 facets the metropolitan areas are ranked and their rates of change compared. This study uses the best available descriptive serial data, while highlighting the deficiencies and recommending means of improving such data. Suggestions are made of means for future gathering of inter-city attitudinal data. The uses of urban indicators as descriptors of change and as aids in establishing an agenda for further action or research are discussed.

S-MP1.5. Quantitative Assessment of the Concentrated Employment Program. W. J. LEININGER.

This paper reports the findings of a study assessing nineteen urban Concentrated Employment Program (CEP) centers. CEP is the first attempt to systematize an integrated delivery of manpower development services to the disadvantaged (determined basically by income level). Results point to the importance of regional and individual program parameters in determining relative CEP effectiveness and of the need for improved follow-up of enrollees and the systematizing of program information.

S-MP1.6. Study of the Need for Educational Manpower for Handicapped Children and Youth RAY MINTZ.

The essential problem of this study was the requirement to translate the needs of the various components of the handicapped child population for special education services into requirements for manpower to satisfy these needs. In recognition to the influence exerted on requirements by the method of education, a program approach was selected. With this approach, the educational needs of a target group of handicapped children are translated into manpower requirements on the basis of the program. The advantage of this approach lies in the ability it provides to capture both the influence of program choice on manpower requirements, as well as the range of personnel types required.

S-MP1.7. Criteria Weighting: Inter-Method Stability and Consistency of Preference in an Urban Planning Application. CHARLES C. SCHIMPELER, NORMAN R. BAKER and WILLIAM GRECCO.

The purpose of this research has been to develop quantitative methods for weighting community decision criteria and to indicate how these weighted criteria could be used in the evaluation of alternative plans. Emphasis is placed on a statistical analysis of criteria weights obtained. A hierarchy of generalized goal categories and specific objectives is developed along with an associated weighting of these decision criteria. Community political structure and decision-making are studied relative to the formulation of goals and objectives and to plan implementation. The hierarchy of goals and objectives is an effective tool for both decision-making and professional planners in the application of community value systems in the development of public improvement programs.

S-MP1.8. Environmental Quality and Environmental Pollution: Some Problems of Definition, Classification and Measurement. ROBERT B. SHAIN.

In this paper, we examine questions of definition, classification and measurement associated with environmental quality and environmental pollution. What is environmental quality? Can useful and meaningful classifications of environmental quality be defined and measured? For which of these classes does the concept of environmental pollution have relevance? How can environmental pollution be classified and measured? These questions are discussed from the points of view of the sciences—physical, biological and social—as well as from the standpoint of legislative and administrative requirements. Included in the paper are examples of operational definitions, classification schemes, and measurement systems.

S-MP1.9. Community Education Planning in Anacostia, Washington, D. C. DONALD STROPE.

In response to President Johnson's recommendation in 1968, a committee assembled by the Office of Education selected Anacostia to be an experiment in the concept of the community school, emphasizing community involvement. A workshop was convened

consisting of over 300 Anacostia residents, teachers, and students to identify educational needs of Anacostia and to establish programs to meet those needs. RMC assisted workshop members to design the programs and determine the resource implications of each of the broad-ranging programs. With knowledge of the costs, workshop participants were able to reconsider their priorities in light of the required resources, in a sense performing intuitive group cost-benefit analysis.

S-MP1.10. Systematic Evaluation and Allocation of United Community Welfare Funds to Various Programs, Agencies, and Services. MARTIN I. TAFT

A generalized methodology for the systematic evaluation of alternatives is applied to the funding allocation problems of a Midwest United Community Welfare Fund organization. The paper describes some of the problems arising from rapid changes in community needs and priorities, resistance to change within the organization, and the unproductive relations between the professional staff and community lay leaders. The process by which long-range community goals, objectives, criteria, weighting factors, and utility functions were developed is traced and the use of such methods as brainstorming and the Delphi Method is presented. The entire methodology was implemented with the aid of a comprehensive time-sharing computer programs known as EVAL. The need for solving the "people problems" related to the introduction of advanced analysis and management technologies is emphasized.

S-MP1.11. Extensions of Activity Allocation Models in Urban Planning. RICHARD D. WORRALL.

An activity allocation model is designed to allocate predicted levels of total regional "activity"—e.g., total regional population, white-collar/blue-collar employment, etc.—between a set of smaller subregions or "districts." This paper describes the development of such a model for the Washington, D.C. region, and discusses its possible extension both to provide a basis for estimating future sub-regional requirements for "urban public services" and as a mechanism for evaluating the costs and benefits associated with alternative planning policies.

S-MP2.1. Governmental vs. Non-Governmental Conflict Resolution. A. CAROL.

This paper reports on a simulation study contrasting the results of conflict resolution under conditions of democratic majority voting and voluntary agreement. Three general problems are examined. In the first two, the minority interest runs counter to the majority. But, in the second, external gains of joint effort are present. The third problem is that of the "free rider", in which all parties may have a common interest, but in which a minority may attempt to escape paying its share.

S-MP2.2. Marginal Stockholder Tax Brackets and the Clientele Effect. EDWIN J. ELTON and MARTIN J. GRUBER.

The determination of marginal stockholder tax brackets is an important and unresolved issue in the economic literature. This paper presents and tests a method of determining marginal stockholder tax brackets and explores the implications of these tax brackets for corporate investment policy, corporate dividend policy, and the assumption of market rationality. A model is developed which shows that the ratio of the fall in stock price on the day a stock goes ex-dividend should be equal to the ratio of one minus the marginal stockholders income tax rate, to one minus his capital gains tax rate. The model is tested using data in all stocks listed on the New York Stock Exchange which paid a dividend between April 1, 1966 and March 31, 1967. Our estimate of the average marginal tax rate of 35.1% agrees closely with previous attempts to estimate stockholder tax rates by examining tax returns.

S-MP2.3. The Application of Decision Analysis to Multiple Sourcing of R&D. VICTOR FUNG and WARREN BRIGGS.

This paper considers the problem of how a government agency chooses an optimal source of action in an R & D program characterized by uncertainties. We first structure the strategy open to the decision maker when two sources are able to perform the R & D

contract, and then analyze the options of using one, or the other, or both sources. The model indicates how soon, and under what conditions, the optimal strategy should be revised in light of information received as the project unfolds. Probability distributions are assessed for the uncertainties of project success, cost and time of development if a source is successful, and the cost and time to detect failure if unsuccessful. The impact upon contractor cost, time and performance of incentive contracts, and of competition are also considered. Finally, a realistic numerical example is given for illustration, and the application is generalized to consider a wide range of optimal make and/or buy strategy under uncertainty.

S-MP2.4. O.R. Based Interactive Financial Performance Analysis. J. C. GRACE.

An optimum integrated plan of operations has a much greater chance of implementation when operating management can quickly compare the calculated optimum against some base plan — and determine the sources of economic advantage. Chances of implementation are further increased when the responsible operating manager can personally make the desired comparisons via computer time-sharing. An interactive financial performance analyzer has been developed for use with a large-scale LP-based operating cost minimization system. The analyzer can be readily broadened to operating profit, net income or profitability. The analyzer in its present form can analyze the performance spread between optimum and base plan by applying the user's choices from a dozen different kinds of cost analysis. The financial performance analyzer will be demonstrated with enlarged video display.

S-MP2.5. The Optimal Deductible for a Given Automobile Insurance Policy. CHRISTOPH HAEHLING VON LANZENAUER.

Most modern automobile insurance systems can be considered as merit rating systems. The structure of a merit rating system gives rise to a number of questions both from the insurance company's as well as from the individual's point of view. For the individual the problem is to decide whether or not to buy insurance and if so, what deductible should be selected. This problem represents a sequential decision process which, in turn, can be solved by dynamic programming. The model is illustrated by sample calculations, and the optimal strategies are compared with the decisions actually made.

S-MP2.6. Capital Budgeting in Continuous Time. ALAN K. HALDER.

Many proposals to handle capital budgeting have used a discrete time dimension, and have foundered upon the problem of ensuring that an investment be completed in a single time period. A framework is suggested for considering the problem in continuous time. In one form this leads to a single machine scheduling problem, but a more realistic formulation leads to a model which may be formulated in control theory terms. Necessary, but not sufficient, conditions for an optimum may be obtained for this model, and it is shown that many poor solutions satisfy the conditions. A branch and bound algorithm is described for which results have been obtained. A further model is formulated to consider interactive investments.

S-MP2.7. When Is A Property "Measureable"? PHILIP HAYWARD.

Portions of OR papers frequently discuss the question of what factors in the situation being analyzed can or cannot be measured or quantified. The question never seems to be resolved in any satisfactory way. It seems not to be realized that, at least from the theoretical standpoint, it can be answered in well-defined terms. The purpose of this paper is to describe the theoretical treatment, with special reference to the problem of measuring effectiveness.

S-MP2.8. Alternative Player Types in Games. LAMBERT S. JOEL.

If the strategy decisions of the rational gentlemen who populate n -person non-cooperative games are circumscribed with new restrictions, if some or all of the players are replaced by paranoids, bullies, Milquetoasts and other undesirables, can we still establish acceptable criteria for stability? The concept of equilibrium is discussed in terms

of formalizations of personality as it affects the scope of strategy choices. The purpose is to provide a framework for enhancing the realism of game models and to identify the consequent mathematical questions. No solutions are offered.

S-MP2.9. A Heuristic Model for the Calculation of Indirect Costs Required on Projects—Uses in Contract Bidding Purposes. TÜRKAN E. KUMBARACA

An experimental study was performed in order to establish a parametric model for the estimation of indirect costs on the basis of calculated direct costs on assembly projects. Month-by-month sums of direct and indirect labor costs, i.e., those incurred by mechanics, electricians, instrumentation etc., yielded a percentage of these costs to total labor involved, as well as a ratio of Ind. Labor/Direct Labor. Observing that large scale projects, in terms of total cost estimates to be added for overhead expenses and indirect labor, could involve an uncertainty of several hundred thousand dollars, a parametric study was attempted to pinpoint which aspects of projects would involve a larger proportion of indirect labor. The linear regression equation that was obtained was tested in inferring indirect costs on a smaller scale project conducted by the same industrial concern. The results yielded good estimates of the Ind. Labor/Direct L. ratio, with a degree of accuracy of .04, less than 1/20 of total range found in the variability of the indirect labor expenditures throughout the duration of assembly. The study was conducted as an industrial consulting project for a nationwide civil and mechanical engineering contracting firm in Turkey.

S-MP2.10. Political Science Applications on Nonmetric Multidimensional Scaling. SUBRATA K. SEN.

This paper explores the application of nonmetric multidimensional scaling in converting survey data into a form amenable to mathematical analysis. The technique is illustrated by questionnaire data measuring voters' views on salient campaign issues in a U.S. Presidential election. Survey data is generally ordinal in nature. Yet, many spatial voting models imply that voter attitudes can be ratio scaled. For example, minimization of quadratic loss if often used as a voter's choice criterion. Empirical validation of such models necessitates the development of techniques to convert ordinal data into at least interval-scaled data. This paper attempts to bridge that gap.

S-MP2.11. Diagnostic Criteria for Evaluation of Health of Laboratory Organizations. ELDON E. SWEEZY.

This study identifies some quantitative criteria which are continuing indicators of changes in the health of the laboratory and its underlying "life processes," and the needs for reinforcement or corrective treatment. In an initial survey of 49 industrial and governmental laboratories, the analog of medical differential diagnosis was used to identify "life processes" underlying observable symptoms. In a sample of four military laboratories, a set of 23 possible quantitative, diagnostic criteria was defined and then experimentally applied in one laboratory for a period of nine months. The paper reports the results of the experimental trial, the methods of analysis, and the possibilities of application to industrial and other governmental laboratories. Some research needs are described.

R-TA1.1. Dynamic Planning of Health Care Systems. C. G. LOVE, R. A. MATHIAS and G. TREBBI.

The planning of both the initial facilities and the expansion of health care facilities in the presence of uncertainty about future demand is formulated as a dynamic programming problem. The entire planning interval is divided into subintervals. At discrete points in time (which define the subintervals), a decision is made concerning the expansion of the facilities during the succeeding subinterval. The objective function at any time is the minimization of expected costs for the remaining portion of the planning interval. The costs considered are acquisition costs (initial construction, expansion, and equipping costs), operating costs (all costs other than acquisition costs incurred in the operation of the facilities; these costs may vary with patient type and load), and penalty costs for having insufficient capacity for the patient load. A specific example of the expansion of a hospital

is considered. This representative example illustrates the usefulness of dynamic programming as a tool in long range planning.

R-TA1.2. Toward an Integrated Methodology for the Analysis of Health Care Systems.
RICHARD D. SMALLWOOD.

This presentation will begin by describing a quantitative analysis tool that has been developed for evaluating alternative designs for medical facilities. This tool consists of four models, a patient arrival model, a patient dynamics model, a care requirements model, and a nursing activity model, these have been interconnected in order to calculate the sensitivity of various economic and care-quality performances indices to changes in the overall design. Some of the more recent results from the application of this model to evaluating alternative designs for a particular medical facility will also be presented.

R-TA1.3. Decision Theoretic Approach to Measuring Burned Patient Severity. **DAVID GUSTAFSON.**

This paper will report on the development and evaluation of a model for measuring the severity of a burned patient's condition. It is based on five independent indicators of patient severity that were measurable on either ratio or nominal scales. The impacts of these independent variables were combined using an additive model where the coefficients were subjectively estimated by physicians experienced in burned patient care, and where the relationship between variables was established by obtaining utility functions from these physicians. The model successfully predicted the choice behavior of physicians in ranking hypothetical patients according to severity. It also led to the hypothesized relationship between severity level and empirical indicators of outcome. The model has implications for assessing the demand for care and measuring the effectiveness of the care.

R-TA1.4. Medicaid Information System as a Tool for Management. **R. J. SALMON, R. SWID S. GERSHENSON and S. GARDNER.**

The Medicaid Program — Title XIX of the Social Security Act by its nature presents highly complex operational problems. The program is open ended with respect to its target population. It provides few incentives to the States for careful planning and cost curbing but virtually commits the Federal Government to pay for a program, the costs of which it does not control. As a result, projection of future resource requirements is extremely difficult. Administrative, fiscal and reporting problems have plagued the program since its inception. This paper presents the results of a pilot project undertaken at the U.S. Department of Health, Education and Welfare to assess the feasibility of developing a Medicaid information system responsive to the needs for efficient program administration and management. The feasibility of implementing such a system within present agency structure is discussed, and some conclusions concerning Medicaid program management and the relationship of Medicaid Information System to improving the management process are presented.

R-TA2.1. Overview of Time-Sharing for Decision Making in the Department of Defense.
HENRY A. LICHSTEIN.

After placing the magnitude of the effort devoted to time-sharing applications into perspective by comparing it to annual DoD expenditures for computer program development, this paper will take a critical look at past, present, and future uses of time-shared and on-line systems in such decision-making areas within the DoD as Command and Control, Logistics Management, and Financial Management. Some of the implications of past successes and failures will be discussed, and a set of criteria for evaluation of systems in terms of their usefulness in an on-line decision making mode will be presented.

R-TA2.2. Cost-Benefit Analyses of Biomedical Information and Communications Services.
RUTH M. DAVIS.

Biomedical information and communications services are so essential to health care and to increasing health manpower that the Federal Government has taken an active role in their development. Such services made available on a national scale are costly. Rational

selection of alternative means of providing them depends upon having measures of their relative utility and demand satisfaction matched against cost. These have proven difficult and sometimes impossible to generate. The Lister Hill National Center for Biomedical Communications has attempted cost-benefit analyses for selected information and communications services. Queuing models, traffic models and community communications models have been used. Results of these analyses related to actual services for the medical community will be presented.

R-TA2.3. A Time-Sharing System for Congress. ROBERT L. CHARTRAND.

The United States Congress has acknowledged the impact of systems technology on our society, and has commenced to avail itself of the innovative tools and techniques. One facet of this activity is the establishment of a computer-centered time-sharing system within the legislative branch. Initial installations are operative in House of Representatives' committees and similar facilities support the research elements in the Legislative Reference Service of the Library of Congress. The presentation will outline the delineation of congressional information requirements, analysis of current procedures, development of alternatives, and the actual step-by-step implementation process.

R-TA2.4. The Potential of Cost-Benefit Analyses to Support Federal Government Policy Making in the Area of Time-Sharing and Data Banks. MICHAEL GOLD.

The Federal Government has been involved in the computer field from its inception, both as a user and as a potential regulator. In recent years, there has been an increasing public clamor against the infiltration of computers, their impersonality and their entrance into daily life. This is particularly true of computerized data banks. The effect of the present introduction of time-sharing and its greater degree of public contact can potentially result in an increase of the current public revolt against scientific and technological developments. This presentation discusses some of the ways in which time-sharing systems might serve to counteract, rather than encourage, this revolt and the subsequent possibility of government regulations of the industry. The argument is made that proper cost-benefit analyses would demonstrate the utility, to the public, of time-sharing and data bank systems.

R-TA3.1. Implementing PPBS in Elementary School. GUSTAVE J. RATH.

A PPBS system has been designed for two elementary schools in Illinois. One program is operational and using a tailor made MIS system. Faculty, administration, and board members participate in key decisions. Systems analysis has been used successfully by school personnel. Analyses on instrumental music, nursing personnel, bus transportation and Fifth Grade French will be discussed. Efforts have significantly changed the administrative practices and are beginning to have long term impact on the educational program.

R-TA3.2. A Cost-Benefit Analysis of University Year-Round Operation. DAVID S. P. HOPKINS.

Year-round operation has often been proposed as a means for achieving an increase in student flow rate without incurring an increase in the university's capital outlay needs. This study investigates the costs and benefits that may be derived by a change from a semester system to operation on a year-round basis. Theoretical calculations of the maximum annual increase in degree recipients are provided under various assumptions. In addition, the experience of the Berkeley campus of the University of California is analyzed in order to demonstrate some actual effects of the implementation of a year-round program of instruction.

R-TA3.3. Emerging Concepts in Education. THOMAS J. BURNS.

New agents for change are presently being explored by the U.S. Office of Education that could be instrumental in reforming key aspects of American education. The theme is educational "accountability for results." The mechanisms under experimentation are: improved management capability for both administrative and instructional activities;

single, well-defined objective function suitable for solution by the simplex algorithm is extremely difficult due to the lack of a common numeraire. This paper develops a technique for combining the several objective functions into a single objective function through a set of implicit weights.

R-TA5.5. Comparison of Psychological-Biographical Characteristics of Drinking Drivers from Crash, Citation, and Roadblock Control Samples. M. W. PERRINE.

This study concerns the extent to which alcohol and alcoholics were involved in 1967-68 Vermont traffic crashes and citations and in the population-at-risk. The behavioral portion was designed to identify those psychological-biographical factors which differentiate drunken and problem drivers from the rest of the driving population. The goal consists of developing a regression-weighted psychometric index from those correlates that are isolated. The experimental design specifies eight different samples: fatal injury and serious injury, crashes, driving-while-intoxicated, and non-DWI moving citations, two crash-and citation-free groups, and two roadblock-control groups (one for each type of crash). Differences within and across groups are analysed and presented.

R-TA5.6. Highway Safety Research at the Institute of Transportation and Traffic Engineering at UCLA. HARRY W. CASE.

The research activities of the Institute cover a wide range of topics within the broad area of transportation, with strong emphasis upon the interdisciplinary approach. Institute research may be placed into eight general categories which, in turn, are divided into many sub-areas. The general categories are: human factors in transportation, accident prevention; driving simulation, human simulation, accident data analysis; psychological and physiological factors related to traffic safety; transportation theory, systems analysis and operations research; transportation economics and administration and systems planning.

S-TA1.1. Problems in Measuring Transportation Impedances. JANE DUBERG.

In addition to the directly measurable quantities of time and cost, a "convenience" or "service" measure of common carrier passenger systems is necessary in an operations research approach to transportation problems to differentiate them from the always available automobile. The question is what characteristics and what ways of measuring them are the most meaningful. One currently employed solution is presented which attempts to differentiate modes by their frequency of service between terminal pairs in a transportation network. The problems of using it in conjunction with a demand prediction model for the Northeast Corridor Transportation Project are discussed.

S-TA1.2. Queuing with Control on the Arrival of Certain Type of Customers. MECKINLEY SCOTT.

This paper deals with the analysis of a queuing model involving two classes of customers with the same type of service requirement. One class of customers can always join the queue; whereas for the other class, entry into the queue is being controlled by imposing certain rules based on the queue length. Using the supplementary variable technique, determination of the equilibrium distribution of the queue length is reduced to that of solving a set of linear equations. When service time has exponential distribution, these equations are easily solved and the queue length distribution is determined completely. Some important characteristics of the queue are also discussed.

S-TA1.3. Use of Psychological Scaling Techniques in Transportation Problems. KENNETH HEATINGTON.

Psychological scaling techniques were used to evaluate several traffic information descriptors. These descriptors have been evaluated as to their desirability on the part of drivers residing in the Chicago Metropolitan Area. This technique of psychological scaling was used to provide inputs to the design of a freeway driver information system. Specifically seven descriptors at the level of heavy congestion, six at the level of moderate congestion, and six at the level of no congestion were evaluated. The descriptors fell into

three broad classifications a) descriptive information, b) quantitative information, and c) no information.

For all levels of congestion, traffic information was preferred to non-information about traffic conditions. For the level of heavy congestion, information relative to an accident having occurred causing heavy congestion was the most preferred descriptor of the total sample. The descriptor speed ranked second to the accident descriptor for the level of heavy congestion and was the first choice for the other two levels of congestion. The two remaining descriptive terms (excluding the accident descriptor) were scaled fairly high, but were less desirable than the term speed. The two quantitative terms of delay and travel time had relatively low scale values and were simply not desired by the respondents.

The various psychological scaling models developed were statistically acceptable and provided a more economical alternative to some design concepts.

S-TA1.4. Study of Safety Standards and Motor Vehicle Inspection Requirements for Used Motor Vehicles. STANLEY KALIN.

A study was conducted to determine the adequacy of motor vehicle safety standards and motor vehicle inspection requirements and procedures for used motor vehicles in each state. An investigation was made of the effects of programs authorized by the National Traffic and Motor Vehicle Safety Act of 1966 upon such standards, requirements, and procedures. The study objective was to provide the basis for work to be initiated by NHTSB to design and implement programs, plans, and procedures which will provide the basis for used car safety standards, inspection procedures, and remedial actions commensurate with established national policy.

S-TA1.5. Environmental and Social Cost Impacts of Transportation System Technologies. ARMANDO M. LAGO.

This study quantifies the environmental and social cost impacts of the transportation system technologies under consideration for the Northeast Corridor. Transportation technologies included in the analysis cover VTOL, STOL, High-Speed Rail, Tracked Air Cushion Vehicles, as well as conventional take-off and landing aircraft, bus, and auto. The environmental and social impacts categories reviewed are air pollution, noise, aesthetics, and safety. The effects of air pollution, noise, and aesthetics are quantified by estimating their effects on land values. A summary tableau of 1975 dollar impacts on environment are presented for each transportation system strategy in the Northeast Corridor.

S-TAT.6. The Traffic Loss at a Merge-Point Controlled by Non-Feedback Regulation. JOEL LEVY and MARTIN H. PEARL.

This paper works out the details of a Markov-chain model for control of a traffic stream at an intersection. The control rule studied is a cyclic one in which the intersection is open to the stream for k periods, closed for l periods, etc. In each period there is a known probability p that a new arrival in the stream will occur, and in each period at most one vehicle can pass through the intersection. Equations which determine the mean "traffic loss" or "turn-away" rate in terms of k , l , p and the maximum queue length d are derived. Computations, using these equations, are reported on. Under the assumption that $l = k+2$, the period of the control cycle is found which minimizes the traffic loss.

S-TA1.7. A New Class of Models for the Modal Split of Transportation Demand. D. E. VAN TIJN and E. DAVID ABRAMS.

Most modal split models currently in the literature are generalizations and variants of gravity models originally developed for predicting total transportation demand. Their mathematical form is largely log-linear. Existing models do not account for effects observed in recent mode choice data and behavioral studies, such as the insensitivity of the modal split to small changes in a mode, and the important effect of access and egress time. A new class of models is suggested, together with a data analysis methodology, which would be sensitive to such effects. These models should be used in conjunction with gravity models for predicting total demand.

S-TA1.8. Decomposing a Traffic Control Problem. J. B. WILLIAMS.

We consider a theoretical problem of controlling congestion in a network of airports linked by arcs with fixed times-to-traverse. The problem of finding optimal landing/

departure mixes at each airport subject to local processing rate limitations is solved with the use of a linear program. The analysis continues with an investigation of the usefulness of various methods for decomposing the linear program.

S-TA1.9. Two Measures for Describing Queue Behavior. U. NARAYAN BHAT.

When a queuing system has reached steady state the probability that the system is busy is considered as the utilization factor (the fraction of time during which the system has been busy) for the entire system. But no factor has been introduced so far to measure the utilization and effectiveness achieved in the system for finite time. This paper defines two such measures and investigates their convergence properties in some detail. These are: (i) utilization factor which gives the fraction of time during which the system is expected to be busy and (ii) effectiveness factor which gives the ratio of the lengths of time during which the system is expected to be busy and idle respectively. For the sake of convenience these are expressed relative to their steady state values. Tables are provided for these two measures in many special cases.

S-TA1.10. Serial Queues with Interference. IRWIN W. KABAK.

Conceptually a serial queue with interference is one in which arrivals (departures) do not have free access to (from) idle servers. This paper addresses itself to an analysis of three types of serial queues with interference. Specific equations are written for the case of two servers; methods of solution are indicated.

S-TA2.1 Simple Bounds with Application in Stochastic Critical Path Analysis. ROBERT A. AGNEW.

Simple bounds are obtained for the distribution function of the maximum of a finite collection of random variables and for the probability that any given random variable is maximal. In the context of stochastic critical path analysis, this corresponds to bounding the critical path length distribution and the individual path criticalities. Empirical results obtained by applying these bounds to "real world" networks indicate that they may be tight enough to be useful in many practical applications.

S-TA2.2. Optimum-path Algorithms: Applications in Transport Operations Analysis and Management. WILLIAM D. CASSIDY.

General characteristics of transport networks are developed upon a set-theoretic basis which becomes the frame for specification of the computational logic of algorithms for solving the problems of optimum path weight between two nodes, optimum path links between two nodes, minimum spanning tree for a node, equivalent completely connected networks, network decompositions and optimum path through decomposed networks. Application of these algorithms to transport networks in planning and operating functions is discussed. Final section of the paper covers characteristics required in data bases for effective application of the algorithms in transport operations.

S-TA2.3. The Backtracking Method of Solving the General Multi-Commodity Flow Problem. HANNAH CHEN and CHARLES G. De WALD.

The special structure of the general multi-commodity flow problem permits a Dantzig-Wolfe decomposition of the problem into a master problem and a set of subproblems. Following the decomposition, a special algorithm for solving the master problem is developed. This algorithm treats the inverse of the basic matrix implicitly by using a backtracking technique. The backtracking technique is similar to the stepping-stone method in transportation problems; instead of forming a loop with corners at the basic variable cells, the backtracking technique forms a tree with the branches terminating at these cells.

S-TA2.4. Congestion Analysis of Dynamic Flow Networks: An Operational Approach. CHARLES G. De WALD.

Initially, a deterministic, dynamic and non-linear "congestion operator" is defined. A sequence of these operators are analyzed to expose the imprinting effect of each operator

on the resultant outflow. This imprinting effect is utilized in a congestion analysis. Secondly, congestion operators and linear delays are sequenced. It is demonstrated that the linear delays can be transformed from the sequence leaving a set of terminally-equivalent congestion operators with modified capacities. This permits a congestion analysis identical to the first case. Thirdly, a time-varying decision (routing) operator is combined with modified congestion operators and linear delays. Transformations and analysis analogous to the two preceding cases are presented.

S-TA2.5. Minimum Cost Flows, Negative Cycles and Positive Loops. MICHAEL FLORIAN, PIERRE ROBERT and MAURICE ROSSIN-ARTHIAT.

We consider first the minimum cost flow problem when the costs are linear (convex). We describe a direct search method to locate negative cycles in a graph, that is based on the properties of negative partial sums of finite sequences. Computational results with the adaptation of this method for the assignment problem are presented. Then, we consider the minimum cost flow problem when the costs are concave and there are capacities on the flow over each arc. The set of extremal flows contains an optimal solution of this problem. We characterize these flows as follows: A flow is extremal if and only if every positive loop contains at least one arc where the flow is at capacity. We apply this property to special structure network flow problems and characterize optimal solutions.

S-TA2.6. A Computer Comparison of Labeling Algorithms for Calculating Shortest Path Trees. JUDITH F. GILSINN and CHRISTOPH WITZGALL.

Computer programs for the two basic labeling algorithms for calculating shortest path trees have been run on a variety of network types, including different size grids, complete networks, and randomly generated networks. Several list processing techniques for improving the basic algorithms, such as the use of tree-sorted lists and forward pointers, have also been tested. The comparative running times to be reported indicate how these improvements affect the relative efficiencies of the two basic algorithms.

S-TA2.7. Optimizing Sorting Networks. WILLIAM A. HORN.

The network design problem considered here involves mail which is sorted progressively to a number of final destinations by traveling through a network of sorting machines, each with one input channel and a fixed (for all machines) number of output channels. Cost for sorting is taken to be the sum of individual costs for sorting to each destination; this in turn is the product of mail volume to that destination times a "disutility" per unit of mail for the particular path in the network to that destination's "sink". A simple algorithm and a dynamic program solve the cost minimization problem completely for certain types of disutility functions.

S-TA2.8. A Sequential Deletion Algorithm for the Design of Optimal Transportation Networks. ARTHUR D. O'CONNOR and CHARLES De WALD.

This paper considers transportation systems composed of a network of limited-access guideways, conveying small, captive passenger vehicles under automatic control. Attention is focused on the problem of connecting a set of passenger-vehicle terminals with guideway links, in an optimal fashion. A multicommodity flow model having step-wise-augmentable arc capacity is formulated. Total system costs are represented by a nonlinear function of arc capacities and flows. A user-acceptance criterion is formalized as a constraint on permissible vehicle routing. A sequential deletion algorithm is derived, which converges efficiently to a feasible and minimum cost network configuration.

S-TA2.9. Enumerative Algorithms for Solving a Class of Network Synthesis Problems. ROBERT D. SANDERSON.

A class of network flow problems having a combinatorial nature is defined. A network is synthesized by including exactly one directed arc from each of several disjoint subsets of possible arcs. All candidate arcs in a particular subset connect the same pair of nodes, and associated with each arc are five parameters: a cost of inclusion, unit cost of flow, lower and upper limits on flow, and direction of positive flow. When a network is

- synthesized, a least cost feasible flow is computed. The objective of the problem is to synthesize the network for which the total cost—costs of inclusion plus costs of flow—is least. In certain special cases the problem reduces to a linear minimum cost flow problem, but more frequently an enumerative technique is required. Branch-and-bound and implicit enumeration algorithms are formulated and compared. The algorithms are specialized for three applications. plant location problems, cost-time critical path scheduling with non-convex costs, and critical path scheduling under disjunctive constraints.

S-TA2.10. The Fixed Charge Network Problem. BERNARD YAGED, JR.

This paper extends the usefulness of the contraction algorithm for minimum cost routing for link cost functions with fixed charges. Instead of basing the algorithm on marginal cost pricing, average cost pricing is used. Good solutions to the fixed charge problem satisfy both types of local stability criteria. An attractive feature of this algorithm is that convergence is fast (less than 10 iterations) and one may converge to graphs with various numbers of links by varying one parameter. Application studies are presently being undertaken and preliminary results are quite encouraging.

S-TA2.11. Finding the K Shortest Loopless Paths in a Network. JIN Y. YEN.

This paper presents an algorithm for finding all K shortest loopless paths from one node to another in an N -node general network. The significance of the new algorithm is that the computational upper bound of the algorithm increases only linearly with the value of K . When the value of K is moderate, the computational upper bound of the new algorithm is extremely small as compared with the computational upper bounds of the existing algorithms proposed by Bock, Kantner, and Haynes (1957), Pollack (1961), Clarke, Krikorian, and Rausan (1963), Sakarovitch (1966), and others.

R-TP2.1 Computer Aided Laboratories in Inventory Systems. E. NADDOR.

Four programs for an Inventory Systems Laboratory will be described. Balancing Carrying, Shortage, and Replenishing Costs; A Deterministic Reorder Point—Lot Size System; A Probabilistic Reorder Point—Lot Size System; A General Inventory Systems Simulation. The purpose of the programs is to assist students in understanding inventory systems, constructing mathematical models, and in finding optimal decision rules. In all programs the user must specify the unit costs and the demands for inventory. The programs provide inventory fluctuations, simulations, expected averages, and total expected costs. The philosophy of preparing the programs, the methods involved, and the experience in using the programs will be discussed.

R-TP2.2. Operations Research and Computer Science—The Interface. R. E. NANCE.

Relationships between the disciplines of operations research and computer science are identified in order to focus on similarities and differences in their educational perspectives. The effect of interactive computing is viewed as part of a larger question involving the two disciplines and their areas of interaction. Consideration of the sub-disciplines in which operations research and computer science have overlapped leads to speculation as to the future areas of overlap. The academic programs in the Computer Sciences Center at Southern Methodist University, which emphasize the interface areas of operations research and computer science, serve as examples.

R-TP2.3. OSCAR—An Interactive Language. Instructional Use in Operations Research and Statistics. V. JOSEPH BOWMAN JR.

This paper discusses the use of OSCAR, a high level interactive computer language, in the instruction of students in operations research and statistics. The capabilities of the language are described and applications to instruction in operations research and statistics are illustrated. In particular, examples in the areas of linear programming, integer linear programming, and regression analysis are presented. The reaction of students to the language is analyzed with particular attention to those students who have had no previous experience with computer programming.

R-TP2.4. Interactive Computing in Operations Research Education at the Graduate School of Industrial Administration, Carnegie-Mellon University. G. L. THOMPSON and D. P. GAVER.

The interactive use of remote computer consoles as an aid in teaching operations research has grown in importance yearly at Carnegie's G.S.I.A. We have found that the opportunity to draw upon various programs applying specific mathematical techniques, (e.g., linear programming and probability models) allows students to readily experiment with various approaches to real problems and cases. Such operations have been popular with students, enabling them to efficiently develop a feeling for technique behavior. By this time experiments with computer administration and graded tests and exercises is in progress.

R-TP3.1. Mathematical Methods of Optimization for Multi-Objective Transportation Systems. KAILASH C. KAPUR.

Transportation systems have multi-objective functions and there are multifactor decision situations. A general mathematical optimization model for such systems is developed which has broad applications for the planning, system design and evaluation of many transportation systems. Three types of solution techniques are discussed. For multi-objective linear programs, a solution is obtained which satisfies the decision maker's preferences and optimization from the decision maker's point of view is considered. A goal programming solution technique is given when goals for the system can be defined. If this is not possible, an overall utility function is defined on the various objective functions and a concept of additive utilities is explored and a parametric programming solution is given.

R-TP3.2. A Time-Dependent Modal Split Model for Commuters. WALTER HELLY, ISRAEL PRESSMEN, and HARRY YAGODA.

Existing modal split models, for the prediction of commuter diversion to new or improved transit facilities, generally are time-independent statistical discriminant functions. Because they embody no descriptive methodology for customer reaction to environmental change, they correctly predict modal choice only some years after a new transit facility is instituted. The present, time-dependent model recognizes three phases of customer response to change: (1) immediate reactions based on extant automobile ownership, behavioral and trip characteristics; (2) reactions following the opportunity to change car ownership or dedication; (3) long term reactions involving changes in trip patterns and land use. The time dependence is modeled as a diffusion process. The model is illustrated by application to past transit improvement with known results.

R-TP3.3. Estimating Automated Network Grid Spacings Which Minimize Costs. MICHAEL B. GODFRED.

One of the few objective techniques which are available for estimating first-cut approximations for network design parameters dates from a 1960 Chicago Area Transportation Study (CATS) paper. This technique estimates arterial and expressway grid spacings which minimize the sum of construction costs and travel costs for a given trip pattern. The principal purpose of the present paper is to draw attention to this method of minimum-cost spacings. In addition, the technique is slightly generalized and reformulated in terms of a continuous trip-length distribution, in order to simplify both analysis and calculation. Minimum-cost grid spacings are calculated for a network of automated roadways (where vehicles are guided and routed automatically), and the sensitivity of the grid spacing to various trip, cost, and routing parameters is explored.

R-TP3.4. Isolation of Speed Effects and Capacity Effects on Efficiency of Cargo Ships. ROBERT L. HAMSON.

Cost effectiveness models using published data evaluate cargo ship efficiency, in terms of vessel capacity, speed and type. Efficient ships should be, first, as large as practical, second, designed for optimum speed (which always exists with speed-dependent friction), and, least important, a surface vessel. Segregation and quantification of capacity, speed and type effects on efficiency are significant contributions to marine engineering as

R-TP3.5. Optimal Location of Intermediate Facilities in a Transshipment Network. DAVID H. MARKS, JON C. LIEBMAN and M. BELLMORE.

An optimal algorithm is presented for the optimal location of intermediate facilities within a general transshipment network. A special feature of the formulation is the assumption of a fixed charge plus linear variable cost and an upper bound capacity constraint for each potential facility site. A branch and bound approach based on using the out-of-kilter algorithm to evaluate subproblems is presented and shown to guarantee optimality. Computational experience with several large problems is shown.

R-TP3.6. Solution of Multi-mode Traffic Assignment Problems By the Duoplex Method. M. J. BECKMANN and H. P. KÜNZI.

The duoplex methods in linear programming seeks out that constraint whose normal towards the interior has the largest angle with the gradient of the objective function, and determines the optimum in that hyperplane (by means of the simplex method). In many cases this yields a good approximation to the optimum solution and in any case a feasible solution which may be improved by simplex methods. It is applicable also to convex problems with linear constraints. In this paper the method is demonstrated for certain traffic assignment problems in multi-mode networks. These include the case of fixed demands and constant travel times and transportation costs (linear programming) and of demands depending on trip costs and travel time, and of transportation costs and travel time depending on flow. To keep the model transparent, only two modes and two modal attributes (time and money) are considered, but generalizations are indicated.

R-TP3.7. The Development and Use of a Model for Cargo Load Planning. J. C. TENNANT.

Airlines conducting freight operations on a large network can improve their profitability and customer service by making maximum use of the capacity offered by their scheduled freighter aircraft and in the belly compartments of passenger flights. Satisfactory space utilization and optimum performance require that the cargo allocation on each flight leg take into account the overall performance on the network. This can be accomplished through the use of a linear programming model which maximizes delivery performance subject to demand, time, and operating constraints imposed by the organization and the behavior of the shippers. This kind of model can be used for planning purposes and, with some adaptations, as an aid to day-to-day cargo operations.

R-TP3.8. Analytical Models for Air Terminal Design. R. D. WORRALL and J. M. BRUGGEMAN.

A series of elementary models of passenger processing in an air terminal are presented, set in the format of a succession of elementary queuing processes embedded in a framework of physical transfer times and distances. Separate models are presented for terminal arrival rates, check-in and ticket-purchase, aircraft boarding and de-boarding, baggage retrieval, and terminal departure. The model(s) accept as input varying levels of passenger demand and varying physical/functional terminal configurations—including alternative staffing arrangements, functional combinations of terminal processing activity and innovative technology. The models' output takes the form of estimated distributions of passenger processing-times and delays associated with a particular terminal configurations. The efficiency of alternative terminal designs may then be tested by varying the set of input parameters for each model, and comparing the resulting processing times/delays with the equivalent levels of capital and operational cost. Field data for model calibration and testing was collected at National and Dulles airports in Washington, D. C.

R-TP4.1. Bureaucratic Rewards as a Constraint Upon Technological Innovation. RICHARD B. HOFFMAN.

Change in the systems which provide "public goods and services" in our urban sector has been viewed as a major domestic problem in America. To understand much of the lack of innovation and continued resistance to change in our urban agencies, it is useful to examine the personal reward systems in these agencies. This paper focuses upon the rewards available to the agencies' managers. The implications for innovative behavior, and the constraints implied by the existing risk-reward framework serve to introduce the

R-TP4.2. Some Effects of Changing Technology Upon the Organization of Scientific Inquiry. VAUGHN BLANKENSHIP.

The traditional model of the scientific investigator has been that of the 'individual' entrepreneur. In this model, there is a minimal division of labor and the individual investigator's control over his own work is complete. Numerous authors argue that the emergence of 'big science'—large scale technology, complex research tasks, and big money—in certain areas have altered this traditional model, changing the researchers' role, elaborating the division of labor in inquiry, increasing interdependence and reducing the investigator's control over his own work. These hypotheses are tested with data collected from a national survey sample of scientists who have been actively engaged in experimental research in the past five years. The groups in the sample have been engaged in (1) 'traditional' research, (2) space research involving the use of high altitude equipment, orbiting observatories, or deep space probes, and (3) research in both environments. Their responses to a series of questions about the organization and conduct of their work under these contrasting conditions are compared with discipline (e.g., physics, biology, astronomy) and institutional affiliation—university, government, industry. The implications for the impact of technology on scientific inquiry are then discussed.

R-TP4.3. Technology Encounters Bureaucracy: Change in the New York City Fire Department. R. W. ARCHIBALD.

Early in 1968 RAND began working with the New York City Fire Department on several problems basic to the delivery of fire protection service for New York City. In this paper some of the major issues are analyzed to assess the varying impact of technological, methodological and bureaucratic constraints on successful implementation of proposed policy changes. Specific attention is given to the role of the analyst as an agent of change in a highly politicized social system.

R-TP4.4. Panel on Technological Bureaucracy. DIETER HAUSSMAN, JOHN T. O'HAGAN, and S. ROSENBLUM.

Here we attempt to bring the varied viewpoints of an operating official from the involved agency, a professional consultant, and an academic to provide an analysis of the effects of the changes described in Mr. Archibald's paper on technology and bureaucracy. The need for individuals having the subject organization's perspective becomes even more important when we are evaluating programs in organizations whose objectives are not profit-oriented.

S-TP1.1. The Optimal Allocation of MIRV Missiles. JOE BARTLETT.

The optimal assignment of a strategic force which does not consist of MIRV missiles can be handled by Everett's Lagrange Multiplier Method. When the strategic force consists of MIRV missiles, the constraint that the weapons from each MIRV missile can only attack targets in a limited geographical area must be satisfied. The approach to the optimum allocation of MIRV missiles presented here is based on a geometrical interpretation of the Lagrange Multiplier Method. A potential function of the efficiency of attacking targets is constructed and the MIRV missiles are allocated to satisfy the constraint and level the potential. The resulting allocation is felt to be either optimum or near optimum.

S-TP1.2. Simulation as a Methodology for Integrating the Management Decision Process in Naval Aviation. F. J. BELLAR, JR. and F. M. NELSON.

This paper suggests simulation as a technique for achieving data correlation and developing decision procedures using large-scale information systems consisting of related, but functionally and organizationally disjoint, data files. It describes a Simscript simulation model of the naval aircraft engine environment and shows how the model was used to correlate disjoint data files (3M maintenance and flight data, ASO supply data, NARF overhaul data, etc.) and to develop integrated decision procedures. The model has wide applicability and is useful with little alteration to other military and civilian military management environments as those for avionics, armaments, motor pools, and support equipment.

S-TP1.3. Futurology and Military Analysis. JOSEPH BODO.

When establishing a projected strategic or tactical posture, or in postulating a response to a future threat spectrum the analyst has basically two choices: having a design so comprehensive that it is independent of the threat (or defense), or providing credible postulations to predict the future developments and channel the response to counter the expected capabilities. "Research into the future," used as a method toward the latter aim is often said to be based on art and intuition. The aim of this paper is to indicate that a formalization of this process—in the true sense of "futurology"—might be possible. The scientization of the concept involves a synthesis among intuition/heuristics and such semi-formal methods as causal analysis, morphological research and the analysis of synergistic effects. The resulting studies may be oriented toward two objectives. A more detailed discussion of the rationale and the supporting concepts of the above method will be given in the presentation.

S-TP1.4. Recruit Assignment Model. EARL E. BROWN.

The United States Marine Corps has as many as 8000 recruits who are assigned to 100 to 300 jobs a month. Each job has a quota, priority of assignment, and levels at which a recruit will be accepted for a job. High priority job quotas are filled first. If any one priority job quota can not be filled recruits are fairshared within that priority. A computer algorithm is given which maximizes relevant area aptitude test scores, given the above constraints. The algorithm uses the out-of-kilter method and runs on an IBM 360/40 or larger with a disk file.

S-TP1.5. Integrated Facility Requirements Study (IFRS). TOM KYLE.

This paper discusses the development and use of a large-scale simulation model developed for the Chief of Naval Air Training. The purpose of this model is to provide the Navy with a management decision tool that facilitates the determination of changes in resource requirements and total systems costs due to changes in the output from the training process (pilot training rates) or changes in the training (production) process (pilot training techniques). The large-scale model is comprised of several submodels developing logistics support requirements, total base loading, facility requirements, assets position, excess-deficiency, and total system cost. The simulation is operated in a time share mode, enabling management to easily change key input variables in order to address the "what if" type question which must be answered in the planning process.

S-TP1.6. Design Logistic Integration Control Method for Integrated Logistic Support Program Application. DON MANAHAN.

A design logistic integration control capability within both government and industry is required in order to realize maximum benefit from utilization of ILS directives and contractual requirements. A method for effecting Design Logistic Integration Control (Des LOGIC) will be described. Des LOGIC combines engineering analysis techniques with a computerized analytic Reliability/Maintainability/Availability model. It permits design-logistic dialogue at any indenture level directed toward satisfying system level mission reliability requirements, through rapid and consistent evaluation of the sensitivity of system requirement(s) to component design, maintenance, and support characteristics.

S-TP1.7. A Model for Single Searcher Sweep Rates and Its Application. R. Mc CALLUM.

This discussion describes a method of estimating the search rate achievable by a single search against a target which can evade only after being alerted by a counter-detection of the searcher. The search rates achievable are functions of the searcher and hider speeds, and are considered as payoffs to the searcher in a two-person zero-sum game where the player strategies are essentially the search and evasion speeds.

S-TP1.8. Quantitative Analysis of the Dynamics of Fire and Maneuver. C. W. PATTEN.

An analysis employing a computerized simulation of close combat. The quantitative analysis objectives were to explore and explain the relationships between fire support and maneuver units; and to measure the effectiveness of different mixes in type offensive

operations in a mid-intensity conflict. The basic forms of maneuver examined were the envelopment and frontal attack. The scenario depicts the attack of a U.S. Mechanized brigade against the prepared defensive positions of a reinforced motorized regiment in West Germany in the current (1969) time frame. Twenty-four computer runs were made for each of the basic types of maneuver with varying numbers of Blue Maneuver and fire support units. A single measure of effectiveness was devised and the relative effectiveness of each Blue mix was computed. The gain in effectiveness by adding a fire support unit or a maneuver unit was determined for each of the type maneuver using several indicators of effectiveness.

S-TP1.9. Lanchester-Type Models of Warfare and Optimal Control. J. G. TAYLOR.

Several problems of military tactics in land combat are formulated as optimal control problems. The problems are for combat describable by Lanchester-type equations over a period of time with choices of tactics for one side. Choice may reflect any of the following: selection of target types for engagement, timeliness of engagement, fire discipline, weapon system characteristics. Optimal strategies are discussed with reference to the influence of combatant objectives and limited ammunition. Implications for intelligence, command and control systems, and development of small arms weapon systems are pointed out. The descriptive nature of the classical Lanchester theory of combat is discussed in light of this paper's results. Extensions to differential games are pointed out, but the usefulness of such "one-sided" optimization techniques is noted.

S-TP1.10. Optimal Flight Paths Over a Surface-to-Air Missile Threat Area. D. TERRIS.

The method of dynamic programming is used to calculate the optimal path of an aircraft travelling at constant altitude and speed through a SAM threat area. The technique can also be used to calculate the aircraft's probability of survival and could be extended to evaluate the requirements or performance of the aircraft's threat warning equipment. The optimum is achieved by minimizing a "cost function" made up of 1) cost of deviation from the most desirable route, 2) cost of the final offset distance from a desired destination and 3) costs proportional to the probability of kill associated with each SAM site

S-TP1.11. Military Applications of Large-Scale Mathematical Programming Models: Description and Critique. JUSTIN C. WHITON.

There are currently a number of applications of large-scale mathematical programming models being developed for and by the various military services. This paper presents a critical survey of several of these models which range in size from hundreds to a few thousand constraints. The models are described, applications are reviewed, and acceptability of results is discussed. Problem areas associated with typical applications are reviewed, and the resolution of difficulties by the successful modeling groups is discussed. Current state-of-the-art and projected advances in large-scale mathematical programming systems and comments relating to the applications are included.

R-WA2.1. Conjectures on Operations Research Education. SETH BONDER

In recent years the introspection of operations researchers has been directed to the education of prospective OR analysts, with a resultant critical appraisal that they are ill-prepared to solve problems. The purpose of this paper is to continue this introspection by presenting some conjectural thoughts on the education of the O.R. analyst. Areas in which his education is deficient are suggested and some reasons for these deficiencies are discussed. Some possible remedial courses of action are briefly noted.

R-WA2.2. Introduction of Problem Orientation in an Engineering-Economic Systems Program WILLIAM K. LINVILL.

The Engineering-Economic Systems program at Stanford links applied mathematics, engineering, and economics with experience on practical problems in the field of systems analysis and decision-making. The paper describes the program, the allocation of effort to theory and practice, the kinds of intern relationships established with public agencies and the feedback of these relationships to the university research program.

R-WA2.3. Panel Discussion on Education for Operations Research in the Public Sector.
SETH BONDER, JACK BORSTING, WILLIAM LINWILL, JOHN D.C. LITTLE, and
E.S. SAVAS.

The panel will discuss the special problems associated with operations research education relevant to the problems of the public sector. The panel will focus on such questions as the aspects of operations research in the public sector that are different from other areas of application, appropriate mix of theory and practice in the curriculum, means for introducing into the educational process experience with formulation and modeling of real problems, approaches to establishing and maintaining relationships with public agencies, and means for fostering interaction between public officials and faculty and students. The emphasis will be on exploring approaches in these areas, especially ones that have already been tested. The panel will examine the problems that have been experienced and attempt to formulate appropriate new approaches.

R-WA3.1. A Multi-Variate Analysis of Factors Affecting Transit Bond Referendums.
ARMANDO M. LAGO.

The rejection of \$3,263 million of transit bond issues in the 1968 Transit Referendums, with Atlanta, Los Angeles, and Seattle voters rejecting rapid transit bond issues, bears out the fact that voters' acceptance is the main bottleneck hampering the implementation of the proposed systems. This study contends that voter behavior in the referendums is predictable and determined by important variables—including transportation system design characteristics, size of the bond issue with respect to general revenues, per capita level of property tax in the area, as well as social characteristics of the community. Using multi-variate analyses techniques the relative importance of factors that affect referendums are quantified, and the models estimated are put through the task of investigating transportation systems designs and financing strategies which would have led to their implementation.

R-WA3.2. Planning and Considerations for the Mexico City Metro. **BERNARDO**
QUINTANA

Mexico City (the Federal District) is the seventh largest city in the world. The metropolitan area contains 20% of the Mexican population, 55% of the industry and more than 60% of the daily work force. The population of the Capital has quintupled in the last thirty years. Such rapid growth creates many strains on city facilities including transportation. Mexico City transportation facilities supply more than 8 million trips per day, 76% on public transportation. Ninety-five bus and trolley systems operate on the streets of the city; on some streets as many as 18 lines share the right-of-way. To compound the problem, the number of automobiles is increasing rapidly, assisted by superhighways, urban overpasses, extensive parking facilities and the desire of people to enjoy the convenient and liberating qualities of automobiles. Public transportation has become neglected. The solution to these problems lies in balancing and coordinating the various forms of transportation. Considering the need to preserve the effective functioning of the City, the addition of a subway is the only reasonable solution. The Metro will provide ample capacity at reasonable cost. Financing this kind of project is a large task but can be done without exceeding the budget of the Federal District.

R-WA3.3. Political Acceptability and Economic Feasibility of Center City Transportation Systems. **JANE-RING CRANE and ELIZABETH PARKER.**

This study examines a number of transportation systems whose primary impact has been on the center city. Recommendations regarding transportation issues frequently are based on limited observations, rather than a systematic analysis of past proposals and systems. It attempts to describe how political acceptability and economic feasibility of center city transportation proposals are affected by (1) the characteristics of the transportation systems, (2) the local economic and political environment, and (3) the local and Federal financial priorities. Transportation proposals and systems are analyzed for common or similar elements which may have contributed to their success or failure.

R-WA3.4. An Approach to Resolving the Transportation Impasse. CHARLES F. BARNES, JR.

In developing the location and design aspects of major urban highway facilities, the transportation planner is always faced with the problem of conflicting goals—metropolitan goals on the one hand, neighborhood goals on the other. At the metropolitan scale, improved circulation and accessibility can hardly be considered as anything but good. However, this is not always the case at the neighborhood level. In fact, at the neighborhood scale (wherein neighborhood is defined as the sociological entity in comparison to a political subdivision) major highway facilities such as freeways seldom improve accessibility nor, as usually constructed, the environment of the area through which they pass. Thus, the statement “everyone wants highways, but not in their backyard” makes a great deal of sense. The proposed approach to break this impasse is to recognize that major highway facilities are valuable to the region, but generally result in severe negative impact to the neighborhood through which they pass. Once this fact is recognized, the suggested program would determine what the neighborhood wants, or needs, in turn for making available to the region the right-of-way required for the metropolitan highway system. In one sense, this could be looked upon as the neighborhood blackmailing the region. However, in another context this approach could be just as well considered as recognizing the (economic) “rent due” to the neighborhood providing a regional facility.

R-WA4.1. Planning in PPBS MIKLOS WASS De CZEGE.

This paper describes the framework for relating the individual planning efforts in a PPB system. The implications of the participatory nature of governmental decisionmaking is described and a model for relating the various participants in a comprehensive planning process is developed. The strategy for planning in traditional planning systems is contrasted with the strategy for planning in a PPB system. Emphasis is given to the relationship between the political bargaining process and comprehensive decision making as implied by a PPB planning system and alternative organizational pattern and their implications for the balance of power relationships within an organization is discussed.

R-WA4.2. Participatory Planning in a Structured Environment; Planning for the Management of the State Educational Agency. NED WETMORE.

This paper describes the development of a systematic process for participatory decisionmaking in a State Education Agency. The described system focuses on the three sets of responsibilities common to the management of state education agencies a) planning for the conduct of affairs of the state education system. b) planning for the conduct of the affairs of the state education agency. c) planning for the conduct of managements own affairs. Three inter-dependent strategies are utilized to carry out these planning responsibilities. Program plan reporting to establish a dialogue between the various participants in the decision process. Follow-up budgeting to establish a means of comparing actual to planned performance. Problem identification and solution strategy to identify and evaluate problem areas.

R-WA4.3. Participatory Planning in an Unstructured on Environment, Planning for a transitional education program. MICHAEL HARDER.

This paper describes the development of a systematic process for planning for a transitional education program whose purpose is to prepare students from ghetto highschoools for technical schools, colleges, and universities. Participants in the planning process are a consortium involving community members, five institutions of higher learning, business, labor organization, and a local school. This paper describes a process for establishing a dialogue in an unstructured environment for determining policies affecting the future direction of the transitional education program. Two strategies are discussed; program development to plan for current activities and strategic planning to focus on broad directions for the transitional education program. It is expected that the two strategies will merge as experienced is gained with program organization.

R-WA4.4. Organization in PPBS. MIKLOS WASS De CZEGB.

Power and strict accountability for its use is central to the PPB idea. Organization in a PPB system refers to the establishment of patterns of accountability within a government. This paper develops a model for defining patterns of accountability within a PPB system. This model has three primary components: An objective function which defines the decision unit, a responsibility function which defines the patterns of responsibility for carrying out work, a transformation function which translates the objectives of an organization into specific assignments. Some of its implications for the managing of organizations are discussed.

R-WA4.5. Organization for Management Decisionmaking: The Development of a PPB Problem Oriented Budget. PHILIP SALISBURY.

This paper describes a process for overcoming the rigid analytical perspective which typifies both the line item and the program budget. In addition to the regular agency budgets an additional inter-agency problem oriented budget focusing on broad problem which cut across agency lines is developed. One effort at the development of this approach for application to the problems of poverty is discussed. The advantage of the problem oriented approach as well as the difficulties involved in its application are described.

R-WA4.6. Organization for Management Decisionmaking: The Development of a PPB Decision Scenario. LARRY HAMILTON.

This paper describes the use of the PPB Decision Scenario as an aid to effective organizational decisionmaking. Specific applications are described in four major areas. These are: Developing an Information Base for Management Information Systems, Performance Evaluation, Translating Planning Objectives into specific assignments, Developing a PPB system. A brief discussion of the design and development of a decision scenario is presented.

S-WA1.1. Scheduling Problems at a Time-Sharing Computing Center. SANT R. ARORA and AMARLAL KALRO.

Time sharing facilities provide easy access to users who individually either do not need or cannot afford a computer of their own. The priorities assigned to programs of various users and the segmentation rules followed determine the ultimate service level. As such it is necessary to devise sound scheduling algorithms to process various jobs. Scheduling has to be done in a dynamic environment and often with incomplete information regarding processing times. This paper examines some appropriate scheduling schemes and associated problems of quantification of service standards provided by these schemes. Problems of determining rate structures for different service levels are also examined.

S-WA1.2 Job-Shop Scheduling with the Branch-and-Bound Approach. SAID ASHOUR and S. R. HIREMATH.

This paper is concerned with the solution of the job-shop scheduling problem where each job has a different machine ordering. The branch-and-bound technique has been applied to this problem. Two new methods of obtaining the bound have been developed. Computational experiments have been conducted to investigate the solutions obtained by five bounding procedures. The number of nodes explored and the computational efficiency have been considered as bases for evaluation. The branch-and-bound technique without backtracking have been used in solving the same set of problems and the quality of solutions obtained have been investigated. Significant results are given and the effects of change in the size of problems on the above criteria are also included.

S-WA1.3. The Scheduling of Resource Constrained Activities. J. S. CLARK.

We apply integer programming, dynamic programming, and other techniques to optimally schedule activities competing for resources. Each activity has a deadline and a value function which equals its maximum for a certain completion time and declines monotonically thereafter. The problem is a generalized capital budgeting problem. We

present an integer formulation of the problem, methods of problem simplification, and a comparison of both exact and approximate integer and non-integer algorithms which exploit problem structure.

S-WA1.4. Optimal Control of a Maintenance System with Variable Service Rates. THOMAS B. CRABILL.

This paper describes an optimal policy for the operation of a maintenance system with a fixed number of machines which break down exponentially. The operator of the service facility may choose one of a finite number of exponential service rates at any point in time. Assigning costs for the use of the different service rates and the downtime of machines, the optimal policy minimizes the long run expected cost rate for the system. The optimal policy is derived by modeling the system as a continuous time Markov decision problem.

S-WA1.5. Economic Aspects of Scheduling Theory. JATINDER N. D. GUPTA.

Several optimality criteria are being used for solving the scheduling problem. These criteria have economic interpretations. A general optimization criterion, called minimization of opportunity cost, is proposed for the scheduling problem and it is shown that the various optimality criteria currently prevalent in literature represent the components of total opportunity cost. Results of a sensitivity analysis of various criteria, performed to determine the effectiveness of various prevalent optimality criteria, are reported according to which none of the criteria minimizes total opportunity cost. These results are then used to establish the importance of each criteria (which reflect the components of total opportunity cost) with respect to the general criterion.

S-WA1.6. A Simulation of a Highway Maintenance Depot. WILLIAM G. HALL.

A simulation model developed to provide highway maintenance management with a quantitative means of evaluating the effect on productivity of different job scheduling and resource allocation policies is described. A typical maintenance unit is responsible for a variety of maintenance tasks on the road net of a geopolitical subdivision. Although units differ considerably, each has tasks which are heterogeneous in terms of magnitude, predictability, and priority. The allocation procedure described allows for part day, full day, and multiday assignments with distinct levels of interruptibility.

S-WA1.7. Algorithm and Analysis of Multi-Resources Allocation. M. USMAN KHAN.

In this paper a resource allocation algorithm is presented, which allocates resources on the basis of strings of activity and reviews the situation after completion of each string. This algorithm allocates several types of resources and each type of resource in multiple units to each activity simultaneously. A discussion is also included on the planning of the resources if the estimates of available resources are to be made available on (a) day to day basis or (b) on a week to week basis for project duration. In long term estimation and planning of several types of resources, each type of resource is required in multiple units. The effect of level-loading expensive resources, while less costly resources are made available in quantity is explored as a concept for project planning, and the results of the test cases are included.

S-WA1.8. Optimal Resource Allocation/Leveling in Engineering/Construction Projects. T. PRABHAKAR.

Engineering/construction projects differ from normal project scheduling problems in their size and complexity of activity/resource requirements; the latter arising from, for example, labor union regulations and desires. These projects can involve as many as several thousand activities and they provide a formidable difficulty for computer solution. This paper presents a 0-1 integer linear programming solution which is highly flexible so that almost any type of restriction can easily be incorporated into the model. The paper shows how certain interesting aspects of the problem enable solution by this approach technically and computationally feasible which normally would be highly impractical in such cases. It is also shown how this resource allocation program works in conjunction with a project

scheduling program such as PDM (Precedence Diagramming Method). Finally, an illustrative problem and program implementation on computer are discussed.

S-WA1.9. An Implicit Enumeration Approach to the Optimal Solution of the Three-Machine Scheduling Problem. ASHOK RAO.

Currently, the most effective approaches proposed to solve the classic three-machine scheduling problem employ the branch-and bound techniques. Recently, the implicit enumeration technique has gained prominence in the solution of the general integer programming problem. This technique does not suffer from the inherent storage limitations of the branch-and-bound technique. This paper applies the implicit enumeration approach to the solution of the three-machine scheduling problem. Necessary conditions are formulated to enable the effective exclusion of certain sequences, hence decreasing the number of solution modes that must be examined. The approach is illustrated by the use of pertinent examples and suggestions are included for its extension to the multi-machine single-sequence scheduling problem.

S-WA1.10. Efficient Solutions of the Resource Constrained Scheduling and Assignment Problem. ROBERT W. L. THOMAS.

The problem of scheduling with resource constraints is considered in terms of a monotonic function of activity completion dates and an optimal schedule is defined as that which maximizes this function. Sufficient subsets of all feasible schedules are identified and theorems relating to the validity of the problem reduction methods are proven. This enables the problem to be regarded as one of activity sequencing, and by judicious resource assignments the redundancy among all possible sequences is maximized. Heuristic algorithms are applied to the reduced problem and examples of solutions for cases with up to 30 activities are cited.

S-WA1.11. A Continental Oil and Gas Supply and Distribution Model. JOSEPH G. DEBANNE.

This systems approach provides a theoretical framework and a procedure to study the supply, distribution and pricing of primary resources such as oil, gas, potash, etc. It was first applied to North America's oil supply and distribution system in order to study the impact of the Arctic oil discovery. Supply and demand centers are represented by source and sink nodes in a transportation network. Supply regions are characterized by a production function relating investments, reserves, capacity and unit cost to price and demand. Transportation links or routes are characterized by a cost of service function relating investments and operating costs to throughput capacity. Demand centers are characterized by a demand forecast and by a price demand elasticity curve when appropriate.

S-WA2.1. An Exposition of the Group Theoretic Approach to Integer Linear Programming. DER-SAN CHEN and STANLEY ZIONTS.

A framework in which the Group Theoretic Approach for Integer Linear Programming due to Gomory and advanced by others can be cast is developed. This framework is based on the convex set formed by the basic and nonbasic variables of the optimal solution to the problem solved as a linear program. The optimal solution for the group problem is developed in this framework, and conditions under which this solution corresponds to the optimal solution to the original integer programming problem are given. Procedures to be taken when the group theory problem solution does not correspond to the optimal solution to the integer programming problem are also given. Methods that utilize the group theoretic framework are then examined in this framework. A number of examples are given.

S-WA2.2. Minimax-Error Disaggregation of a Distribution. A. J. GOLDMAN.

Given exact or approximate probabilities for grossly classified outcomes of a chance event, the problem is to obtain systematically some nominal probability distribution for the outcomes in a finer classification. A minimax-error approach, with "error" defined by

maximum componentwise absolute residual, yields a linear program whose special form admits relatively explicit solution. Componentwise bounds, and/or rankings, and/or "weights", can be incorporated. The full paper will include a unifying account of four previous papers on minimax-type selection of incompletely specified probability distributions, plus a description of several open problems

S-WA2.3. A Computational Study of Dimensionality Reduction Methods in Dynamic Programming. ALBERT GRAY and W. L. MEIER, JR.

Dynamic programming always has been haunted by the curse of [state] dimensionality. Recently two new methods have been suggested for coping with this problem. A recent book by Larson presents State Increment Dynamic Programming and a recent paper by Wong and Luenberger has described a decomposition method. This paper presents results of a computational comparison of the two approaches along with a discussion of the merits of each. A computer code was developed for each in FORTRAN IV and run on the IBM 360/65. Example problems are presented which illustrate the accuracy and utility of each technique.

S-WA2.4. On Construction of a Reference Equation in Simplified All Integer Primal Algorithm (SPA). D. K. GUHA.

A reference equation in SPA can help considerably in terminating the algorithm. In those problems where optimal solution includes some variables at their maximum (or minimum) and at non-integer values, a better reference equation can be obtained by introducing new inequalities constraining the respective variables at their highest (or lowest) integer values. A general suggestion for constructing better a reference equation is made which can be applied to every case regardless of the above situation.

S-WA2.5. A Search Model for Evaluating Combinatorially Explosive Problems. KEITH L. Mc ROBERTS

In the attempt to solve combinatorial problems such as those that frequently exist in plant layout planning, sequencing and scheduling, and routing situations, heuristic algorithms have frequently been developed. In these algorithms there has been no basis available to evaluate the progress of the heuristic results in relationship to an optimum. This paper outlines and provides examples of the application of extreme value distributions and more particularly the Weibull distributions as mechanisms to estimate optimum limits. Given such estimates the paper further illustrates the development of decision rules applicable to the decision of continuing or halting the heuristic analysis.

S-WA2.6 Staff Assignment Under Risk—Some Solvable Nonlinear Zero-one Problems. GERHARD MENSCH.

Allocating a group of people to a set of tasks has been done with the assignment model of linear programming, or abbreviated techniques. In this paper the single efficiency measurements are strengthened by considering the mean and standard deviation, instead. In any case, the objective function must be linear, and the constraint set must be a unimodular system for any solution to be in zero-one-integers. Several stochastic problems are shown to be solvable integrally although either the objective function is nonlinear and/or the constraint system is not unimodular.

S-WA2.7. Generalized Lagrange Multipliers and Linear Programming G. L. NEMHAUSER and W. B. WIDHELM.

Linear programming procedures are developed for searching Generalized Lagrange Multipliers (GLM). The search procedures are based upon cuts in the multiplier space. Each optimization of the Lagrange function yields a cut. The cuts define a convex polyhedral set in multiplier space. The linear programs result from finding "centrally located" interior points to the convex set. One linear programming procedure is shown to be equivalent to a search method developed by BROOKS and GEOFFRION. A second procedure appears to be more efficient. The linear programs converge to the optimal values of the multipliers and either yield an optimal solution to the original problem or indicate a "gap".

• **S-WA2.8. An Experimental Study on Solving Linear Programs. A. RAVINDRAN.**

An experimental study to compare simplex method and Lemke's method to solve linear programs is made. The M3 code for simplex method and the author's code for Lemke's method were used. Comparison was made only with regard to number of iterations each method takes and our little study shows encouraging results about the superiority of Lemke's method, but no recommendation in general is made by the author due to size of study and data. A by-product of our study is a complementary pivot algorithm to solve linear programs which is a modification of Lemke's method and which saves considerable computer storage and time.

• **S-WA2.9. A Revised Simplex Method For Quadratic Programming. MICHAEL RUSIN.**

We present a computational method for solving quadratic programming problems which reduces to the revised simplex method for linear programming when the objective function is linear. Quadratic programs with few quadratic terms are solved with little more computational effort than similar-sized linear programs using the revised simplex method. The basis matrix which is maintained is symmetric and may vary in size from iteration to iteration. Comparisons on artificially generated test problems indicate that the method is more efficient than other available methods.

S-WA2.10. Nonlinear Programming Solutions with Complex Variables. DANIEL TABAK.

A set of nonlinear programming problems is solved involving complex unknown variables which appear either in the nonlinear objective function or in the nonlinear constraints. Since the functions considered involve real value and norm operations, their final value is real, however their general form is complicated. A special unconstrained minimization technique, originally developed by Fiacco and McCormick, which does not require the computation of partial derivatives, is applied in conjunction with the SUMT algorithm. The results obtained by direct application of the NLP algorithm have been verified independently by direct search and graphical techniques.

S-WA2.11. The Solution of Travelling Salesman Problems by Heuristic Algorithms. ROBERT W. L. THOMAS.

This paper discusses various schemes for successive applications of heuristic algorithms to randomly generated planar travelling salesman problems. The efficacy of different seed solution generators for two-opt and three-opt algorithms is considered in detail. Among the seed solution generators employed are Monte Carlo routines, the boundary theorem method, and the "minimum separation" solution. The results obtained to date suggest an order of magnitude improvement in efficiency over the original arc-exchange algorithms for problems with up to 100 nodes.

R-WP1.1. Improving New York City's Housing Code Enforcement Program. STEPHEN R. ROSENTHAL.

The allocation of inspectors' time and effort presents operational and conceptual problems in New York's housing code enforcement program. Due to these complex allocation problems, meaningful improvements to this municipal housing program can be difficult both to formulate and to implement. This paper discusses the code enforcement program from a systems viewpoint including the development of operational decision rules for the allocation of inspectional resources and a penalty structure for failure to comply with the housing code. Implementation plans for the improved system are discussed to illustrate typical environmental factors that affect the ultimate success of quantitative analysis in municipal government.

R-WP1.2. Research for the New York City Fire Department: Dispatching, Deployment and Relocation of Fire Engines. ARTHUR J. SWERSEY.

Upon the receipt of a fire alarm representing an incident of unknown severity, a dispatcher must decide how many and which engines to dispatch. In addition, as engines become busy at fires, the coverage provided becomes geographically imbalanced. Therefore, it may be necessary to relocate, i.e., to move engines from one fire house to another.

This paper describes analytical approaches to these problems and a simulation model of the dispatching procedure which predicts dispatching delays as a function of the alarm rate. As a result, a new procedure was implemented which dramatically reduces the magnitude of delays.

R-WP1.3. A Simulation Model for Spatially Distributed Urban Service Systems. RICHARD C. LARSON.

A number of spatially distributed urban service systems (e.g., police, fire, and ambulance systems) are characterized by a very similar system structure and dynamics. For each system, requests for service which occur randomly in space and time result in the dispatch of mobile units to the scene of the request. We introduce a general simulation model designed to assist administrators in exploring the consequences of alternative operating policies. The simulation reflects the spatial relationships inherent in operations, as well as the sequential time nature of events which is common to many systems. An application to urban police operations is discussed.

R-WP1.4. A Selected Sampling of New York's OR Studies. E. S. SAVAS.

In addition to fundamental systems analyses in the areas of housing and public safety, the City of New York has undertaken a wide variety of projects which utilize the methods of operations research. These include planning for snow emergencies, the cost-effectiveness of forming election districts via computerized redistricting, optimal allocation of the population to community shelters, the implications of weighted voting in the Board of Estimate, improving the emergency ambulance service, analysis of parking regulations, violations, and enforcement activities, and the development of a Geographic Information System as a tool for urban operations research.

R-WP2.1. Family Social Background and Process Factors Involved in the Development of Student Achievement and Motivation. GEORGE W. MAYESKE.

Employing data from a national survey of schools and students this paper describes briefly the reduction of a large volume of data into school and student indices. Using these indices regression analysis is employed to show the roles that the students Social Background (his socio-economic status, family structure and racial-ethnic group membership) and Family Process variables (expectations and aspirations that parents have for them and activities that they engage in with them) play in their achievement and motivation. The role of these two sets of variables is also contrasted with the schools role.

R-WP2.2. Assessing the Side Effects of Educational Programs. ALBERT E. BEATON.

An educational program or treatment may affect many areas of a child's growth and development in ways not explicitly conceived in its design. Most statistical analyses focus on only intended effects, whereas a more complete evaluation would include side effects, desirable or otherwise, as well. This paper will discuss a statistical model which attempts to identify and assess the effects of both intended and unintended outcomes.

R-WP2.3. Hidden Costs of Education: What Should Public Policy Be? DENNIS J. DUGAN.

This paper considers the education process to be one of long gestation in which school resources are but one of the many educational inputs. The total costs of education are derived and included school expenditures and the educational expenditures of parents within the home environment. These latter costs, referred to as the hidden costs of education, are substantial and contribute to the scholastic success of the student. This paper isolates those hidden costs of education and compares them with the costs of formal schooling. With this broad definition of the total costs of education, the following questions of public policy are asked and solutions are sought. How can the government alleviate educational deprivation? Can public policy more efficiently provide education by reallocating educational expenditures among the various forces that influence learning? What is the optimal timing of educational expenditures?

- **R-WP2.4. The Demand For Higher Education in an Urban Area** ARTHUR J. CORAZZINI.
An econometric model of the potential and realized demand for higher education in the Boston SMSA. The model estimates changes in the confrontation of the potential demand for higher education over time and assesses quantitatively the relative importance of measured aptitude and financial constraints in returning places in higher education. Further, the determinants of SAT performance are evaluated with an aim to developing a set of policy proposals for returned investment in higher education.

R-WP3.1. Impact of Reduced Physician Time Per Patient on Cost-Benefits of Multiphasic Health Screening. HARRY E. EMLET, JR.

The time a physician must spend in examination and diagnosis of his patients has been observed to be reduced by Multiphasic Health Screening (MHS). This paper examines how MHS might also affect the time the physician spends in disease management and how the time he spends in all three functions affects the cost-benefits of MHS. It develops means for quantifying the latter relation and identifies modifications that should occur in the author's previously developed model for evaluating the cost-benefits of MHS. It evaluates the magnitude of the impact on cost-benefits both parametrically and with specific values of time reduction suggested by current screening operations.

R-WP3.2. A Systems Approach to Hospital Design TUNG AU and ERNEST W. PARTI.

This paper presents an overview of the application of systems analysis and computer-aided techniques for the solution of complex problems in hospital design. First, the hospital is viewed as a subsystem of a comprehensive health care system in studying the needs. Then, the functional requirements of the hospital system, including patient treatment, staffing and service patterns, are considered in formulating the design criteria. Next, alternatives for providing the needed physical facilities and desired environment, including the layout of rooms and equipment as well as the provision of proper temperature, light, etc. for the spaces, are generated and examined in order to obtain a feasible and possibly a near-optimal design. Finally, basic construction schemes incorporating assignment, sequencing and scheduling procedures to implement the proposed design will be discussed. The potential links of all subsystems to the overall hospital design problem are provided through a common data base. By properly linking the subsystems, the merit of a hospital design can be determined by inputting appropriate values of the causal factors or parameters, and the sensitivity of variations in designs can be evaluated.

R-WP3.3. A Stochastic Model for the Optimal Control of Epidemics and Pest Populations DAVID L. JAQUETTE.

The growth of epidemics, bacteria, pests and other biological populations has often been described by both deterministic and stochastic models. Recently, theoretical work has been done to develop the models incorporating control and, with explicit cost functions, to find optimal control strategies. A birth and death process is assumed to describe a stochastic population process. Continuous time control rules of stopping action type are considered as representing the harvesting, curing, or killing of a segment of the population. The optimal timing and magnitude of the control policy is found to minimize the average cost criterion. Several simplified examples along with extensions of the basic model are presented.

R-WP3.4. The Simulated Health Service Node. JOHN HUNTON MOSS.

This paper develops a set of simulated health service nodes which may be used as building blocks for general and extrapolatable simulations of health systems and subsystems. Three nodes are considered: a simulated personnel health service node, a simulated physical health service node, a simulated self-destruct (consumeable) health service node. Especial consideration is given to the handling of these service nodes in a queuing-oriented simulation in terms of the contemporaneous service of a given arrival by two or more service nodes. Emphasis of the paper is on the utility and value of health system simulation rather than on the program detail of the described service node concept.

The objective of the effort is to improve the utility and applicability of simulation techniques as a methodological approach to improving the economy, availability and quality of health services.

R-WP3.5. Performance Indices For Community Health Programs. JAMES E. MILLER.

One of the major weaknesses present in current methods for evaluating health programs lies in the failure to differentiate between the effectiveness of the treatment and the proficiency of a community directed application effort. There is a tendency to either disregard treatment effectiveness or to assume that effectiveness is equal within all similar types of programs. This paper develops a set of evaluative formulas for application to three different types of health programs. The types are traditionally defined as preventive, control, and curative health programs. The performance indices are derived from specified relationships between treatment effectiveness, population at risk, program effort and estimates of expected program impact. Utilization of these performance indices will provide the decision maker with a commonality of measurement that does not now exist and will facilitate objective allocation of health resources within the defined program areas.

R-WP3.6. Hospital Blood Bank Whole Blood Inventory Control. JOHN B. JENNINGS.

The central activity of blood banking facilities is the control of an inventory of a perishable commodity. The general problem of perishable inventory control is considered briefly, and the development and analysis of a realistic, policy-relevant model of a hospital blood bank is examined in detail. Several operating policies are parametrically explored via computer simulation of the model, utilizing data obtained at a large, general hospital. The results are presented as feasible operating curves which relate the policies to the two primary—but incompatible—measures of effectiveness, shortage (or stockouts) and out-dating (or waste).

R-WP3.7. A Generic Model for the Description and Evaluation of Acute and Chronic Disease Programs. JAMES MILLER, J. L. SANDERS and RONALD CHORBA.

A general model is developed which describes the evolution of a natural population through the identified states of the disease through time. The components of the model are identified for a variety of diseases such as coronary heart disease, tuberculosis, stroke and diabetes. The model is easily modified to incorporate the implementation of control Program efforts. A program evaluation technique is presented which incorporates data on mortality, mobility and disability. Trial results are presented.

R-WP3.8. A Health Delivery System Simulator. WILLIAM HARDING, LANNY MULLENS and ROBERT L. BAKER.

A simulation model of a rural health delivery system is discussed in this paper. The specific nodes described in this model are, in themselves, simulation models. The model is designed to be useful as a community health planning aid as well as a useful tool to health administrators. The model is discussed in terms of its useful application to an urban community with its varied health agencies. The model is also discussed in its relation to management information systems for various health agencies.

R-WP4.1. Interfacing Field Medical Simulations. DONALD J. BOWES, JR.

Upon examination of the restrictive interface between simulations of casualty producing environments and definitive medical care facilities, a multi-dimensional aspect of the interface is revealed. Specifically, relationships of the number of patients acquired vs. level of emergency medical care rendered vs. tactical constraints upon medical facilities and missions evolve. Selected interface parameters, reduced to vectors, facilitate description of patient load/class input to a medical facility as a function of the interface. Techniques of vector analysis, solutions of equations relating mortality/morbidity as a function of patient acquisition, and gaming concepts for optimized decision-making are utilized.

R-WP4.2. Carriers and Land-based Aircraft in ASW. ROBERT MC QUIE.

This paper describes a model of antisubmarine aircraft constructed around a linear programming algorithm. It stations carriers, land bases, and aircraft types to determine how many of which types are required at various locations to obtain the most destructive ASW system. To test its effectiveness, the model was used to analyze the area search and convoy escort missions in the northeastern Atlantic. The report also discusses the effort required to construct a similar model of the entire north Atlantic and the north Pacific. For the ocean area under study, the effectiveness of a system based on land-based P-3 aircraft is analyzed and compared with a system based on carrier-based VS(X)'s.

R-WP4.3. Evaluation of Multi-Mode System Effectiveness. D. W. CHRISTENSEN and D. TERRIS.

A general automated technique has been developed to calculate the effectiveness of systems which perform multiple, serial functions. Each function may be performed by one of several operational modes according to a priority scheme. Significantly, effectiveness is accounted for down to the component level, even though any given component may be critical to several modes and functions. A FORTRAN IV program has been written to implement this technique which is based on a vector-matrix approach proposed by the Weapon System Effectiveness Industry Advisory Committee (WSEIAC). It has been successfully applied to the cost/effectiveness analysis of a combat fighter aircraft's fire control system.

R-WP4.4. A Game Theoretic Model for Allocating Aerial Interdiction Effort. GERALD R. MC NICHOLS.

A family of simple game theoretic models has been developed to evaluate allocation alternatives in an aerial interdiction environment. This family of analytic models allows varying levels of detail and hence, comparisons between alternative strategies and policies. A large part of the paper is devoted to a Carrier Attack Model in which a logistics network is represented as a set of arcs. These arcs are then combined to provide supply routes on the one hand and armed reconnaissance flight paths on the other. This model is solved by the application of linear programming to obtain optimum throughput and allocation strategies for both sides. These simple analytic models have been more useful than a simulation model because the entire process can be more carefully controlled.

R-WP4.5. Mathematical Programming: A Military Production Planning. FREDRICK C. WESTON, JR.

This paper illustrates a production (ordinance) scheduling problem where more than one organization is involved. It represents the production line of several activities. Several ordinance type products are being produced with constraints as to which activities and production lines can produce each item. The problem represents a situation where assignment of work load and thus funding is controlled at a central source. This central source is responsible for meeting work load scheduling and also minimizing total cost of production over all products produced on various production lines within designated organizations. The problem can incorporate exogenous variable such as the costs of components or materials that may be acquired from more than a single source. Also, transfer or shipping costs can be added. Thus, the model can assume a system orientation in that both input and output can be optimized along with actual costs of production at each of the activities.

R-WP4.6. Computerized Selection of Aircraft Spares Inventories. S. C. MOORE, R. D. GILBERT, R. W. MC MICHAEL, and W. M. FAUCETT.

A procedure is presented for determining base inventory quantities for multiple indentures of aircraft spare parts. The basic unit is an analytic optimization technique that maximizes aircraft availability and minimizes special handling cost for specified investment constraints. A probabilistic description of base operations is utilized to formulate an integer non-linear programming problem which is solved using Lagrange Multipliers. Two optimization inputs, demand and repairability rates, are products of a Bayesian inference

technique that incorporates engineering estimates and operational data. Selected inventory are evaluated by simulation of base operations, facilitating performance comparisons, between optimized inventories and those selected by conventional procedures.

S-WP1.1. Projection of Technological I/O Co-efficients. ARTHUR CAROL and ISRAEL PRESSMAN.

This paper attempts to relate technical production patterns among nations in various stages of economic development. For some two dozen nations, input-output co-efficients (showing demand requirements of industries for a given output for each industry) have been compared. To the extent that these I/O co-efficients change as a function of the stage of economic development, it may be feasible to better plan such development. Thus industry requirements can be forecast for target levels of development.

S-WP1.2. Computation of Optimum Planar and Location Strategies for a Stationary Spare Satellite. T. S. CHIDAMBARAM.

Given the need of a single spare satellite in stationary orbit as replacement for a possible failure among n operational satellites, we ask: where do we locate the spare and in what initial orbital plane? A satisfactory answer must consider not only the mechanics of replacement but also the economics of fuel consumption and time to replacement. A mathematical model which reflects all these factors is constructed and analyzed to yield definite numerical answers to the above questions.

S-WP1.3. The Application of Tactical Decision Models to Inventory Management. R. I. GREENBERG.

This paper deals with the omnipresent problems inherent in many inventory management systems. Emphasis is placed on developing algorithms for the more common, non-mathematical situations found in many business systems. Whereas much has been written about long range strategic decision models with Bayesian properties, this paper will attempt to show how operations research techniques can be applied to the somewhat complex tactical decision processes normally performed by clerical or low level supervisory personnel. Discussions of optimal techniques for inventory sampling as well as techniques for handling the utilization of available material through a flexible computerized process will also be included.

S-WP1.4. Control Model Simulation. EDWIN HULLANDER.

A particular problem of maintaining control of a stochastic production process occurs when defective units, found in the process, are fed back to the line for rework. When rejections occur randomly and are reworked upon discovery, the production line balance become difficult to plan and maintain. This study investigates the behavior of a hypothetical process under various control strategies. The effectiveness of the control strategies are embodied in a digital simulation model. The strategies are examined in respect to process stability, physical and economic efficiencies.

S-WP1.5. Optimum Nuclear Fuel Cycles for an Advanced Converter Reactor—Decision Making Under Uncertainty. J. C. SCARBOROUGH.

This paper formulates, in a systems context, the decision processes a private company faces in determining which nuclear fuel cycle, and variant within that cycle, to develop and offer commercially for the high temperature gas-cooled reactor (HTGR), an advanced converter considered promising for cheap electric power generation in the U.S. This paper presents the long and short term cybernetic requirements to support the firm's fuel cycle selection, the prior probability of successful development based on uranium fuel cycle experience; the joint and conditional probabilities associated with the fuel cycles considered; the sensitivity and specificity estimated for these conditional probabilities, the estimated value outcomes for each of the decisional acts under each true state; the inferred utility function of the firm based on an extensive form of analysis; and the indicated optimum fuel cycle decision.

S-WP1.6. Computer Simulation of Rotomailer Operations. H. TRAMPOSCH.

A program has been prepared for the digital computer to simulate the operations of a mail inserting machine, called the Rotomailer. A limited number of runs were conducted to show the effects of various parameters upon the production rate of the machine. Considered were speeds up to 20,000 cycles per hour. The greatest single effect was observed when the thickness of material in one of the eight feeders was increased from .010 inch to .100 inch; the productivity of the machine when operating at 20,000 cycles per hour decreased from 61% to 33%. Confidence in the simulated model was established by correlating the computer results with actual production runs. The predicted productivities were 60% and 77% for two separate days, the actual values turned out to be 60% and 74%, respectively.

S-WP1.7. Engineering Design Optimization Under Risk. by JOEL WEISMAN and A. G. HOLZMAN.

Since engineering designs generally involve a number of elements about which only partial information is available, design optimization should be conducted under conditions of risk. Since utility is non-linear with cost or revenue, the enterprise's view of risk is considered through utilities designed to costs or revenues which deviate from the mean. This is termed "risk programming" to distinguish it from previous contributions in this area. General forms of the objective function, yielding expected utility are derived for utility functions of two types. When the total cost distribution is normal, an exact solution requiring only a knowledge of expected total cost and the cost variance is obtained. For non-normal cost distributions, an upper bound of the objective function, requiring knowledge only of the same two quantities, is obtained. A model for engineering design, which provides both the expected total cost and cost variance is developed based upon division of the elements of variability into several categories. With this division, a reasonable computational procedure is possible. The procedure has been incorporated into a modified direct search optimization program capable of solving large-size design problems.

S-WP1.8. Stationary (s, S) Policies for a Finite Horizon. ALAN C. WHEELER.

In the finite-horizon stochastic (s, S) inventory model with periodic review, the parameters of the optimal policy generally vary with the length of the horizon. A stationary policy, however, is easier to implement and may be easier to calculate. This paper studies optimal stationary policies for a finite horizon and relates them to optimal policies through their relation to optimal stationary policies for an infinite horizon.

S-WP1.9 Probabilistic Evaluation of Helicopter Lift Capability. D. G. BROWN, E. LEVY, D. R. LIMAYE and R. A. OREN.

This paper describes a technique for the calculation of the probability that a helicopter can lift a specified load, or number of loads with a specified frequency distribution, in a given geographical region. This probability is computed by determining the bivariate altitude-temperature probability distribution for the specified region. The payload capability at any given temperature and altitude is calculated using standard performance equations. Integrating this over the altitude-temperature distribution, it is possible to obtain the probability distribution of payload capability, from which the required probabilities of lifting specific loads can be determined.

S-WP1.10. Patterns and Determinants of Common Stock Price Volatility. EDWARD I. ALTMAN and ROBERT A. SCHWARTZ.

The proposed research centers around a detailed analysis of common stock volatility measures and patterns over time. Our objective is three fold. We wish to present, in relation to the prices of individual common stocks, measures of total stock price volatility, market related volatility, and volatility which is unique to a particular firm's stock. We will systematically examine the effect which alteration of the time span, over which the volatility statistics are computed, has on the time series stability of the statistics. Econometric models (regression and discriminant) will be specified to identify the

determinants of stock price volatility and to further our knowledge of the accuracy of ordinal (ranking) and cardinal (point estimates) classifications based upon our volatility statistics. In pursuing this analysis, we will be exploiting a body of volatility data that we have already developed for firms selected randomly from the Standard and Poor list of 500 common stocks. The data extend from the first quarter of 1962 through the last quarter of 1968.

MINUTES OF THE ORSA COUNCIL MEETING

The Thirty-Sixth Meeting of the Council of the *Operations Research Society of America* convened at 10:00 AM on 11 November 1969 at the Americana Hotel, Miami Beach, Florida, with Thomas E. Caywood, President, presiding. The Council reconvened at 2:20 PM, adjourning at 5:00 PM to reconvene at 6:50 PM on 11 November. The following items are reported from the meeting. (Complete minutes are obtainable from the Secretary of ORSA.)

FUTURE ORSA MEETINGS

No.	Dates	Location	Chairman
37	20-22 April 1970	Washington, D.C. Washington Hilton	HOWARD M. BERGER <i>Business Products Group</i> <i>Xerox Corporation</i> <i>Xerox Square</i> <i>Rochester, New York 14603</i>
38	28-30 October 1970	Detroit Statler Hilton	RICHARD C. JELINEK <i>Bureau of Hospital Administration</i> <i>4th Floor City Center Building</i> <i>220 East Huron</i> <i>Ann Arbor, Michigan 48108</i>
39	5-7 May 1971	Dallas Sheraton Dallas	RONALD L. GUE <i>The MEDICUS Corporation</i> <i>1104 Expressway Tower</i> <i>Dallas, Texas 75206</i>
40	27-29 October 1971	Los Angeles Disneyland Hotel (joint with SSCG)	GERHARD L. HOLLANDER <i>Hollander Associates</i> <i>P.O. Box 2276</i> <i>Fullerton, California 92633</i>
41	26-28 April 1972	New Orleans Jung Hotel (joint with AIIE)	JOSEPH L. BALINTFY <i>School of Business Administration</i> <i>Tulane University</i> <i>New Orleans, Louisiana 70118</i>
42	November 1972	Atlantic City	ROBERT M. STARK <i>University of Delaware</i> <i>Newark, Delaware 19711</i>
43	Spring 1973	Milwaukee Sheraton Schroeder	JAMES F. BANTON <i>Rex Chain Belt Inc.</i> <i>P.O. Box 2022</i> <i>Milwaukee, Wisconsin 53201</i>
44	12-14 November 1973	San Diego	JOSEPH V. RAVENIS, II <i>Res. & Adv. Tech. (7-17)</i> <i>General Dynamics Electronics Div.</i> <i>3090 Pacific Highway</i> <i>San Diego, California 92112</i>

IFORS: The Fifth Triennial Conference on Operations Research in Venice, 23-27 June, was attended by 78 of the 94 invited ORSA members (eight other ORSA members attended by other means). The General Meeting on 22 and 25 June voted to accept ORSA's motion requesting IFORS to take future management responsibility for IAOR from ORSA, and also to accept ORSA's invitation for a special international conference on cost-effectiveness, with IFORS as sponsor and the Cost-Effectiveness Section of ORSA as host. ORSA is to name one member to serve on the Programme Committee of the 1972 International Conference in Dublin.

LANCHESTER PRIZE COMMITTEE: The Council approved the awards of the 1968 Lanchester Prize to Anthony V. Fiacco and Garth P. McCormick for their book *Nonlinear Programming: Sequential Unconstrained Minimization Techniques*, John Wiley & Sons, 1968; and to Philip M. Morse for his book *Library Effectiveness, A Systems Approach*, the MIT Press, 1968.

PUBLICATIONS. ORSA members and other subscribers will be offered the 15-year index to *Operations Research* at two special prepublication prices through mid-December 1969. The index is to be updated annually. *Operations Research*, with 1136 pages, meets the request for a 10% total-page reduction. The committee of IFORS appointed to plan the future of IAOR is expected to issue a report which the Council will consider at the ORSA national meeting in April 1970. More funds for publicity to increase the circulation of *Transportation Science* will be requested, following a mass mailing of promotion brochures in February 1970. Newsletters of Sections of ORSA are not to be printed in the *Bulletin*.

SECTIONS. A new Technical Section, Urban Affairs, was approved to study applications of operations research to urban systems. A prize of \$250 for the best paper read for the first time at a geographical section meeting in 1970 was approved on a one-year-only trial basis.

EDUCATION COMMITTEE: Under a second grant of \$6700 from NSF, the Visiting Lectureship Program began its third successful year. The brochure "Careers in Operations Research" is to be distributed, starting in December 1969. From the workshop of the Education Committee on 9 November, held in conjunction with the Miami meeting of ORSA, and meetings of a subcommittee, recommendations for undergraduate requirements for a graduate program in operations research were to be submitted at a later date.

NOMINATIONS: The following slate has been announced by the Nominating Committee:

Vice President/President-elect

Secretary

Treasurer

Council (two to be elected)

ALFRED BLUMSTEIN

ROBERT E. MACHOL

MARTIN N. CHASE

ROBERT M. OLIVER

KENNETH W. YARNOLD

CLINTON J. ANCKER, JR.

ROBERT HERMAN

JOHN D. C. LITTLE

MICHAEL E. THOMAS

(By petition, RAOUL J. FREEMAN, candidate for Vice President/President-elect, will also appear on the ballot. Ballots with biographies will be mailed to Members.)

MEMBERSHIP: As of 24 October 1969, there were 2368 Members, 4568 associate members, and 841 student associate members, for a total membership of 7777.

NEW MEMBERS: The Membership Committee reported its nominees for full Membership in the Society. The following were elected by the Council as new Members.

Adelman, Irma
Arma, James K.
Baker, Robert L.
Barney, Gerald O.
Bauer, Christian S.
Belur, Radhakrishnan K.
Borneman, David R.
Boyce, William M.
Buc, Bernard J.
Carter, Cecil V.
Carter, Earl L.
Dawson, Peter P.
Dick, Ronald S.
Donaldson, John L.
Esogbue, Augustine M.
Eusanio, Lawrence A.
Florian, M.
Fox, Karl A.
Gasser, Robert E.
Gerrard, John P. D.
Greenberg, Harvey J.
Grike, Leo J.
Hamson, Robert L.
Harvey, Roy P.
Hawes, Mary K.
Heaney, James P.
Hellman, Louis P.
Howard, Gilbert T.
Hullander, Edwin L.

Huysman, Jan H. B. M.
Iglehart, Donald
Ingbar, Mary Lee
Ivanov, Yuri N.
Jarvis, John J.
Johnson, Philip A.
Jugenheimer, Robert W.
Kaung, Thomas T. S.
Keilson, Julian
Klein, Meyer
Kline, Melvin B.
Korte, Bernard H.
Kotler, Philip
Large, Joseph P.
Lenell, Richard A.
Leone, Michael A.
Lifson, Melvin W.
Luenberger, David G.
McMahon, Edward P.
Mendum, Joseph H.
Miller, William O.
Neiss, Joseph A.
Orden, Alex
Papageorgiou, John C.
Patinkin, Norman
Payne, James R.
Peck, Lawrence D.
Pedrick, Perkins C.
Peker, Altan M.

Pfaff, Martin
Pope, Kenneth R.
Price, George
Radnor, Michael
Reardon, William A.
Reisman, Arnold
Rhodes, William D.
Ronchetti, Robert
Rossbach, Janice
Ryan, Joseph T.
Sa, Graciano
Saalmans, Peter D.
Salmon, Raphael J.
Scarborough, Jack C.
Seelig, Jakob W.
Sherbrooke, Craig C.
Sidro, Pier G.
Summons, Kendall W.
Simpson, Robert W.
Stanley, Walter L.
Stewart, Maco
Stimson, David H.
Thompson, David D.
Tierno, Ralph T., Jr.
Ushakov, Igor A.
Williams, Jerry O.
Williams, Robert D.
Worrall, Richard D.

ROBERT E. MACHOL
Secretary

TREASURER'S REPORT

Santa Monica, California
January 9, 1970

Audited figures for the Society's financial performance during 1969 are not available in time to be published in this *Bulletin*. However, the figures presented below give a pretty good picture of where we stand. To summarize, the Society and its publications are now, on the whole, doing better than breaking even and our net worth has increased by about \$34,000 during 1969. This situation contrasts very favorably with our financial results in 1968. You may notice the enormous importance of our publications to our overall financial health. The income of the general Society is only around \$76,000 a year, while that of our publications totals nearly \$200,000 a year. Providing we keep our publications on a sound financial basis, we need not expect a recurrence of the money troubles which plagued us in 1967 and 1968. However, dues would have to be increased very sharply if we were to develop an important loss situation in our overall publication efforts.

General Society	Income	\$ 76,367
	Expenses	<u>62,565</u>
	Net	13,802
IAOR	Income	41,874
	Expenses	<u>35,626</u>
	Net	6,248
TRANSPORTATION SCIENCE	Income	10,360
	Expenses	<u>18,845</u>
	Net	(8,485)
OPERATIONS RESEARCH	Income	130,694
	Expenses	<u>104,406</u>
	Net	26,288
PORS	Income	3,344
	Expenses	<u>7,537</u>
	Net	(4,193)
TOTAL	Income	262,639
	Expenses	<u>228,979</u>
	Net	\$ 33,660

KENNETH W. YARNOLD
TREASURER

REPORT OF THE 1968 LANCHESTER PRIZE COMMITTEE

This year the Lanchester Prize Committee followed the practice of recent committees, in making a call for nominations, placed in the January-February 1969 issue of *Operations Research*.

A substantial number of nominations were received from the literature published in 1968. These included both books and papers, and we are pleased to note that a number were from the publications of the Society. Several of these were excellent works, for which the Committee would have been pleased to award the prize with the conviction that the work met the tests defined by the terms of the Lanchester Prize.

After consultation with outside reviewers and discussion together, the Committee ultimately narrowed its choice to two publications. Both are outstanding examples of the literature of operations research, well written and substantial contributions to the field. These are very different in character; one a theoretical exposition, the other a comprehensive and pioneering treatment of applied work. After some discussion we concluded

... to choose between them would be essentially a judgment in taste rather than a comparison of importance or quality. Therefore, the Committee has concluded that the 1968 Lanchester Prize should be shared by:

ANTHONY V. FIACCO AND GARTH P. Mc CORMICK, *Nonlinear Programming: Sequential Unconstrained Minimization Techniques*, John Wiley and Sons, New York, 1968,* and

PHILIP M. MORSE, *Library Effectiveness, A Systems Approach*, The M.I.T. Press, 1968.

In the opinion of the Committee, the Fiacco-McCormick book is an outstanding effort. It presents one of the most comprehensive and successful approaches to the analysis and solution of nonlinear programming problems, and is an excellent organization of research work carried out during the last decade.

The Morse book is a classic in the extension of operations research to an area of application. It combines theory and analysis in masterful fashion, and describes how relevant data can be collected and effectively used in the solution of challenging practical problems. The work makes no pretension to a major theoretical advance, but shows in elegant fashion the relevance of observation, experimentation and analysis to operating and policy questions in the management of a complex system.

The Committee wishes to express its appreciation to all who assisted in its work by offering nominations, opinions, and judgments.

JOHN F. MAGEE, *Chairman*
JOHN E. WALSH
BERNARD B. WATSON
ARNOLDO C. HAX, *Secretary*

November 11, 1969

EDITOR'S NOTE: The Lanchester Prize commemorates the work of Frederick W. Lanchester (1868-1946), an automotive and aeronautical pioneer, who also developed, during the first World War, theories of combat that are now recognized fundamental in military operations research.

Phillip M. Morse was the first President of the Society and is recognized for his work in operations research and in physics. He retired as director of the Operations Research Center at the Massachusetts Institute of Technology last year.

Anthony V. Fiacco and Garth P. McCormick are both members of the staff of Research Analysis Corporation but the latter is currently on leave of absence at the U.S. Army Research Center at the University of Wisconsin. They have developed sequential unconstrained minimization to the point where these techniques are now one of the standard methods for solving nonlinear programming problems.

*Bernard B. Watson, as a staff member of RAC, where the authors are also employed, refrained from discussion or decision on this work.

38th NATIONAL MEETING

The 1970 Fall meeting will be held on October 28–30, 1970, at the Statler Hilton Hotel in Detroit, Michigan. The meeting will be oriented toward, but not restricted to, applications of operations research in commerce and industry. Sessions of invited papers are being organized in the following areas:

I. Special Applications

1. Cost Effectiveness
2. Educational Sciences
3. Health Applications
4. Military Applications
5. Space Sciences
6. Transportation Science
7. Community Planning
8. Libraries
9. Water Resources
10. Safeguarding Nuclear Material
11. Time-shared Queues

II. Common Processes

1. Decision
2. Forecasting
3. Financial
4. Long-range Planning
5. Management Information Systems
6. Marketing
7. Organization
8. Production and Scheduling
9. Inspection

III. Theoretical

1. Mathematical Programming
2. Queueing Networks
3. Simulation

Submission of contributed papers on the above topics or on other subjects of interest to the membership of the Society is encouraged. It is understood that such papers have not previously been published or presented at other meetings. Papers to be included in the program will be selected on the basis of quality of content. Some papers of more than usual interest and quality may be selected for presentation in the appropriate session of invited papers.

Abstracts and titles of papers must be received by May 1, 1970, to be considered. Each abstract should (1) consist of a single paragraph not exceeding 200 words, with no footnotes; (2) contain a heading including title of paper, author's name, professional affiliation, and business address; and (3) be typewritten, double-spaced, and submitted in duplicate. Mail your abstract to the Contributed Papers Chairman: Prof. J. B. Neuhardt, Industrial Engineering Department, Ohio State University, Columbus, Ohio 43210.

Invited sessions will be conducted in the usual sequential style. Contributed sessions will be in the seminar style introduced in San Francisco in 1968. Each author will have a table, chairs, a blackboard, and a sign announcing his paper. For a full session he may discuss his paper with all comers or schedule repeated presentations, as he wishes. The author may use other non-electric visual aids that he brings; no electricity will be available for projectors. When a contributed paper is accepted for presentation, the author will be notified whether it has been assigned to a contributed session or an invited session.

The program is still pliable and suggestions regarding its content are welcome. These should be directed to the Program Chairman: Dr. Hugh E. Bradley, The Upjohn Company, Kalamazoo, Michigan 49001. The General Chairman for the Detroit meeting is Dr. Richard C. Jelinek, Industrial Engineering Department, The University of Michigan, Ann Arbor, Michigan 48104.

39th NATIONAL MEETING

The 39th National ORSA Meeting will be held at the Sheraton-Dallas Hotel in Dallas, Texas, on May 5-7, 1971. Regular sessions on such topics as urban systems, mathematical programming, production scheduling, health services, Markov decision processes, operations research in ecology and biology, simulation as well as many other topics will be held. Concurrently, simultaneous sessions of the seminar style will be used. Contributed papers on all topics of interest to ORSA are invited. Inquiries regarding the program should be addressed to Dr. William Pierskalla, Computer Science/Operations Research Center, Southern Methodist University, Dallas, Texas 75222. Inquiries on all other matters should be addressed to Dr. Ronald L. Gue, The *Medicus* Corporation, 1104 Expressway Tower, Dallas, Texas 75206.

1971 IFORS INTERNATIONAL C-E CONFERENCE

The Cost-Effectiveness Section will host an IFORS International Cost-Effectiveness Conference from April 12-15, 1971, at the Statler Hilton Hotel in Washington, D.C. The conference will be the first one of its type sponsored by the International Federation of Operational Research Societies. About 400 people in the field who will be invited from throughout the world, including Eastern Bloc countries, are anticipated to participate in the four-day meeting.

Dr. W. Edward Cushen, Chief of the National Bureau of Standards' Technical Analysis Division (TAD), is the general chairman of the conference.

The tentative program for the meeting will include reviews of current C-E analyses in the United States and several selected foreign countries, methodology and tools, applications and case studies, operation of C-E analysis groups, and the relationship of C-E analysis to management. Participants will meet first in general sessions, then form nine working groups to discuss various pre-selected topics, and conclude with general sessions. Dr. Nigel Hopkins of the Operational Research Division, Canadian Forces Headquarters, is program chairman. His deputy is John W. Locke, founding C-E Section chairman, of TAD.

Proceedings of the conference will be edited by Dr. Alan J. Goldman of the National Bureau of Standards and a target date for their publication has been set at October 1971.

C-E Section Host

Armand B. Weiss, chairman of the C-E Section and project director at the Logistics Management Institute, is publicity chairman. Mrs. John Locke will handle the ladies' program and hospitality, and Mrs. Alice R. Kelly of TAD will serve as meetings secretary.

Present plans call for inviting 300 people from the United States and 100 people from other countries to participate. Both IFORS and National Societies that are members of IFORS will distribute the invitations. Anyone desiring to present a paper is requested to send an abstract to Dr. Nigel Hopkins, Operational Research Division, Canadian Forces Headquarters, Ottawa 4, Canada, by 10 October 1970, and the full manuscript of the paper by 31 December 1970. Administrative information can be obtained from Lloyd W. Burden, Technical Analysis Division, Building 225, National Bureau of Standards, Washington, D.C., telephone (301) 921-3561.

TIMS MEETINGS

The XVII International Conference of the Institute of Management Sciences will be held at Imperial College, London, England from Wednesday, July 1st, to Friday, July 3rd, 1970 in conjunction with the Operational Research Society of Great Britain. The Operational Research Society will hold its own meeting from Monday, June 29, to Wednesday, July 1, also at Imperial College.

The 11th American meeting will be held October 19-21 in Los Angeles. Alan Rowe and Joe McCloskey are General Chairmen and the deadline for abstracts is May 15, 1970. Subsequent meetings are in Washington (March 1971) and Detroit (September 1971).

1970 NATO MEETINGS ON OPERATIONS RESEARCH

Three NATO meetings on Operations Research are scheduled for 1970:

- "Problems in the Organization and Introduction of Large Logistic Support Systems" to be held in Luxembourg May 18–20.
- "Operational Research in Industrial Systems" to be held in St. Louis, France, July 20–24.
- "Education and Training for Operational Research" to be held in Turkey in September.

Details on participation in these meetings can be obtained from M. A. G. Knight, Scientific Affairs Division (Operational Research), NATO, Brussels 39, Belgium.

INTERNATIONAL SYMPOSIUM ON MATHEMATICAL PROGRAMMING

The 7th International Symposium on Mathematical Programming will be held in The Hague, Holland, September 14–18, 1970.

As in the previous symposia, beginning in Chicago in 1949 through the last one in Princeton in 1967, the primary objective is to provide for interchange of new ideas in mathematical programming. Topics include the theoretical, computational and applications aspects of all phases of mathematical programming, as well as the relationships between mathematical programming and other fields of pure and applied mathematics. For further information write Prof. G. Zoutendijk, c/o Computing Centre, University of Leiden, Stationsplein 20, Leiden, The Netherlands. If you plan to contribute a paper you should indicate a provisional title.

SYMPOSIUM ON NONLINEAR PROGRAMMING

The Mathematics Research Center, U.S. Army, University of Wisconsin, will hold a symposium on Nonlinear Programming, May 4–6, 1970, in Madison, Wisconsin. The symposium will consist of approximately fifteen invited lectures with emphasis on a closer rapport between theory and computation. The program committee consists of O. L. Mangasarian, K. Ritter and J. B. Rosen, Chairman.

15 YEAR INDEX TO OPERATIONS RESEARCH

The 15 year Cumulative Index to *Operations Research*, the journal of the Operations Research Society of America, has been published. Covering Volumes 1 to 15 (1952–1967), this index is a condensed and inexpensive reference and abstracting service in which articles published in *Operations Research* are listed as follows:

- (1) Chronologically, by Title
- (2) A Cross-reference Subject Classification
- (3) An Alphabetical Author Index

All articles appearing in *Operations Research* in Volumes 1–15 have been referenced by a simple four-digit number that identifies and cross-references individual authors, articles and subject matters.

The price of the Index is \$7.50 to ORSA members and \$15.50 to libraries and all other subscribers. Make checks payable to *Operations Research Society of America*, P.O. Box 1254, Baltimore, Md. 21203.

HEALTH PROCEEDINGS AVAILABLE

Proceedings of the ORSA Symposium on Health which was held in Washington, D.C. May 14–16, 1969 are now available. The Symposium was sponsored by the Health Applications Section. Send \$10/copy to John R. Hall, Secretary, Health Applications Section, 5733 N. 27th St., Arlington, Virginia 22207.

OREPS PROCEEDINGS

The proceedings of the Conference on "Operational Research in Electrical Power Systems" which was organized under the aegis of JFORS, by the Hellenic Operational Research Society (HELORS) in Athens in November 1968, are available for \$30.00. Write Hellenic Operational Research Society, 28, Kapodistriou, Athens, Greece.

PUBLICATIONS IN MATHEMATICS

The Editor has received the following communication from Professor Daniel Zelinsky, Dept. of Mathematics, Northwestern University, with the request that Members of the Society communicate their thoughts and concrete suggestions on the present or future methods for paying for journal publication in Mathematics directly to him.

"The Commission of a National Information System in Mathematics, with members representing 11 professional societies, has been studying the problems of communication in an increasingly productive mathematical community. In January, 1969, the Commission established a Committee on Publication Costs which is now working on the specific question of how to meet the growing costs of journal publication.

At present, the committee is not primarily concerned with proposals to eliminate any mathematics from publication, nor with more radical schemes relegating some papers to more limited and less expensive distribution. Rather, assuming that mathematics will follow the history of other disciplines with more mathematicians publishing more mathematics in more journals, we are asking how this should be paid for.

Present devices include subscriptions; subsidies by universities, societies, or government agencies; and page charges. This last has been the target of much criticism and has recently proven unreliable in the face of government expenditure limitations. The concept of page charges originated in the philosophy that publication is an integral part of the research process and the costs of setting forth the results of research (the production costs of the journal) might well be borne by the sponsor of the research. (The presswork, binding and distribution costs are still charged to the journal subscribers.) Page charges are generally borne by the author's institution or a government granting agency; in cases of unsupported research, they are virtually never collected, and in accordance with a decision of the Federal Council for Science and Technology, nonpayment of page charges does not influence the acceptance (and, in mathematics, any other aspect of publication) of the manuscript."

IEEE AFFILIATE PLAN AVAILABLE TO ORSA MEMBERS

The Institute of Electrical and Electronic Engineers (IEEE) has an established affiliates plan which allows ORSA members to join certain of their professional Groups without joining the society. Seven of the IEEE Groups offer affiliation without voting or office-holding rights: Reliability, Information Theory, Engineering Management, Computer, Engineering Writing and Speech, Man-Machine Systems, and Magnetics. Three Groups offer affiliation with full voting and election privileges: Engineering in Medicine and Biology, Geoscience Electronics, and Systems Science and Cybernetics. Annual dues for affiliates of these groups range from \$13 to \$17. (*Ed. Note:* Full ORSA membership is only \$15.) For further information, write The Institute of Electrical and Electronics Engineers, 345 E. 47 St., New York, N.Y. 10017.

INSTITUTE FOR MANAGEMENT SCIENCE AND ENGINEERING AT GEORGE WASHINGTON UNIVERSITY

A new Institute for Management Science and Engineering has been established at The George Washington University with W. H. Marlow as Director. Plans call for the Institute to define and develop new management techniques necessary to keep pace with expanding technology. The Institute will take over existing programs in logistics and assessment of technology at George Washington and will seek additional outside support.

OPPORTUNITY FOR OPERATIONAL RESEARCH IN THE UNITED NATIONS

The United Nations Conference on Trade and Development (UNCTAD) has embarked upon an extensive Ports Research Program. The objectives of this research are the reduction of ship turn-around times and the determination of an economically sound basis for port development. UNCTAD hopes to develop the necessary techniques to advise Governments, particularly those of developing countries, on the formulation of national and regional ports policies.

Although recruitment may not be immediate, they would, nevertheless, like to hear from well-qualified and experienced operations research scientists who may be interested in applying their expertise to the study of Port Development.

The duty station is Geneva, although missions to any part of the world may be expected. Appointments would normally be for fixed terms of one or two years. Fluency in English is essential; a knowledge of French or Spanish is desirable.

Persons interested in applying are invited to forward full details to: Office of Personnel, UNCTAD, Palais des Nations, 1211 Geneva 10, Switzerland.

EDUCATION COMMITTEE

The Education Committee held a conference entitled "Undergraduate Preparation for Graduate Education in Operations Research" on Sunday, May 9, in Miami. Survey and position papers were given by invited speakers. The Committee is at present summarizing the results of the conference.

The Committee has completed writing the brochure, "Careers in Operations Research" and this is being published. The purpose of the brochure is to interest college students in pursuing a career in the field of OR. Anybody interested in obtaining copies of this brochure should write to the Chairman of the Education Committee or to the ORSA business office.

ORSA VISITING LECTURESHIP PROGRAM

ORSA continued its Visiting Lectureship Program for the 1969-70 academic year with sponsorship from the National Science Foundation. The program has the following aims: to stimulate existing operations research courses and programs in universities and colleges which do not at present offer degrees in operations research; to aid and motivate the starting of new operations research courses and curricula, to motivate able students towards careers in operations research; to provide education and information on the nature and scope of operations research, and to provide information and advice to students, student counselors and faculty members on the availability of advanced training in operations research.

Lecturers not only present formal lectures, but are available to discuss teaching problems and curricula matters with members of the staff and to advise students on future opportunities in study and employment. The lecturers are national leaders in operations research in the university, industry and government.

Lecturers for 1969-70 include: Jerry Banks, Georgia Institute of Technology; Albert B. Bishop, The Ohio State University; Alfred Blumstein, Carnegie-Mellon University; Seth Bonder, The University of Michigan; Thomas E. Caywood, Caywood-Schiller Associates; Walter E. Cushen, National Bureau of Standards; Burton V. Dean, Case Western Reserve University; Joseph H. Engel, Communications Satellite Corporation, Charles D. Flagle, The Johns Hopkins University; Raoul J. Freeman, Systems Applications, Inc.; Ronald E. Gue, Southern Methodist University; William Horvath, The University of Michigan; Donald L.

Tiehart, Stanford University; William S. Jewell, University of California; John D. C. Little, Massachusetts Institute of Technology; L. G. Mitten, The University of British Columbia; George L. Nemhauser, University Catholique de Louvain; George E. Nicholson, Jr., University of North Carolina; Stephen M. Pollack, The University of Michigan; Arnold Reisman, Case Western Reserve University; David Schrad, Naval Postgraduate School; Melvin F. Shakun, New York University; Michael E. Thomas, University of Florida; Harvey M. Wagner, Yale University.

For further information, write: Visiting Lectureship Series in Operations Research, c/o Professor J. R. Borsting, Department of Operations Analysis, Naval Postgraduate School, Monterey, California 93940.

SUMMER SHORT COURSE OFFERINGS 1970

Each year, various Universities around the country offer short courses in both elementary and advanced aspects of Operations Research and related areas. The following list includes those schools whose offerings have come to the attention of the Editor.

University Extension
The University of Wisconsin
432 N. Lake Street
Madison, Wisconsin

Department of Industrial Engineering
Stanford University
Stanford, California 94003

Director of Continuing Education
College of Engineering
251 Carpenter Hall
Cornell University
Ithaca, New York 14850

Director,
Department of Continuing Education
Georgia Institute of Technology
Atlanta, Georgia 30332

Center for Advanced Engineering Study
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Engineering Summer Conferences
The University of Michigan
Chrysler Center
Ann Arbor, Michigan 48105

Program Promotion
Post Office Box 24902
University Extension, UCLA
Los Angeles, California 90024

ORSA members should contact these schools directly for information on offerings, dates, and fees.

NSF SUMMER INSTITUTE FOR COLLEGE PROFESSORS

The National Science Foundation is sponsoring a five-week summer institute in management science and operations research at the University of Colorado, Boulder, Colorado, from June 15 through July 17, 1970. The institute is designed for college professors in management science, operations research, applied mathematics, economics, health, and health administration. Participants will be paid a \$500 stipend and travel expenses. Applications must be submitted by April 15. Principal lecturers are: Dr. Egon Balas, Carnegie-Mellon; Dr. David Rutenberg, Carnegie-Mellon; Dr. Ronald Howard, Stanford; Dr. Alex Orden, University of Chicago; Dr. Robert Fetter, Yale. For further information, write Donald R. Plane, Co-Director, Summer Institute, Division of Management Science, Business Building, University of Colorado, Boulder, Colorado 80302.

EDUCATION NEWS

The Education Committee will regularly publish information concerning degree programs in Operations Research. News of new programs or significant changes in existing programs should be sent to Professor J. R. Borsting, Chairman, ORSA Education Committee, Naval Postgraduate School, Monterey, California, 93940

University of Arkansas
Fayetteville, Arkansas

Primary Operations Research:

Operations Research I	Operations Research Theory
Operations Research II	Optimization Theory I – Linear Models
Automated Systems	Optimization Theory II – Nonlinear Models
Mathematical Decision Theory	Industrial Decisions
Systems Simulation	Dynamic Programming
Analysis of Inventory Systems	Analysis of Queueing Systems
Operations Research Techniques	

Associated With Operations Research:

There are also a number of associated courses with Operations Research content offered in the Industrial Engineering Department on such subjects as data processing, statistics, production, and engineering economy.

DEGREES GRANTED

	1968	1969
B.S.	20	27
M.S.	4	9
Ph.D.	1	4

A formal educational program in operations research began at the University of Arkansas in 1963. A degree is offered as an option in the Industrial Engineering Department. The operations research option exists in the Bachelor of Science, Master of Science and Doctor of Philosophy Degrees.

Inquiries should be directed to Dr. Ronald W. Skeith, Department of Industrial Engineering, University of Arkansas, Fayetteville, Arkansas 72701.

DEGREES OFFERED

B.S. in Industrial Engineering (Operations Research Electives)
M.S. in Industrial Engineering (Operations Research Option)
M.S. in Computer Science
Ph.D. (Operations Research Option)

FACULTY

Primary Operations Research: R. M. Crisp, M. D. Springer, R. W. Skeith, H. Taha,, R. Ashfal.

Associated with Operations Research: J. L. Imhoff, J. W. Wilkes.

MEETINGS COMMITTEE

At the Miami meeting, the Meetings Committee approved plans for the 42nd National Meeting to be held in November, 1972, in Atlantic City, N.J., and the 44th National Meeting to be held November 12–14, 1973, in San Diego, California. General Chairmen of these two meetings will be Robert M. Stark and Joseph V. Ravens, II, respectively. The Committee has developed a new meetings information form and is beginning to revise and update the Society's Meetings Manual to aid the smooth operation of the Society's meetings.

TECHNICAL SECTION ACTIVITIES

has six technical sections: Cost Effectiveness, Health Applications, Space Sciences, Transportation Science, and Educational Sciences. These sections are in various stages of development from mature to newly born. The Educational Sciences which was organized in May, 1969.

General newsletters annually to apprise members of news in their field. These newsletters include general items of interest to practitioners in the field, discussions of new developments, reviews of members, bibliographies of literature in the field, and news of the Society.

organize and sponsor sessions at national meetings of the Society and in meetings of other Societies such as The Institute of Management Sciences. The Society also presents monetary awards for outstanding papers. The Health Applications Section presented a Health Symposium in Washington in May, 1969.

Abstracting items are abstracted from Newsletters issued by the technical sections.

Health Newsletter, October, 1969:

With the membership of the Section now exceeds 500, the core group of active workers is considerably smaller. Much larger numbers will be needed to deal with the problems of the health services which already cover a significant portion of our economy. It has been estimated that by 1975 health services will consume 7 1/2% of G.P., amounting to 94 billion dollars annually. It is not just the size of this problem but its loose and informal organization which presents special problems from the point of view. The resolution of these problems will require highly imaginative and creative solutions. It is important therefore that we recruit not only larger numbers of workers but also the more talented ones to our ranks. The newly established National Center for Health Services Research and Development will form the natural focus for this effort. However this Center is still badly understaffed and underfunded, and there is a real possibility that decisions relating to the future organization of the health services may have to be made before adequate knowledge of their consequences has been developed. This possibility emphasizes the urgency of the need for OR studies of the health system and increased effort at the present time when studies can still have an effect on shaping the health care system."

From the C-E Newsletter, June, 1969:

"The deadline for receipt of papers for the Cost-Effectiveness Section's 1969 Essay Contest is September 10.

"Members of the Cost-Effectiveness Section and the profession at large are urged to submit their papers as soon as possible. Papers can be on any aspect of cost-effectiveness analysis. A first prize of \$200 and a second prize of \$100 will be awarded. Papers should preferably be no longer than 25 typed double-spaced pages and should be prepared in the format described in *Operations Research*. Four copies should be sent to: Dr. Laurence E. Lynn, Jr., Chairman, Cost-Effectiveness Essay Contest, National Security Council, Washington, D.C. 20501.

"Prize winning papers and other high quality papers received will be submitted to *Operations Research* for possible publication. The May-June 1969 issue of *Operations Research* published the Essay Contest's 1968 prize-winning paper, 'Cost-Effectiveness in Urban Transportation,' by Edward N. Dodson of the General Research Corp.

"Judges for the contest will be Dr. John Brandl, Department of Health, Education and Welfare; Dr. Donald Rice, Department of Defense; and Dr. Lynn."

From the Space Sciences Section Newsletter, February, 1969:

The Space Sciences Section of ORSA in conjunction with the University of California at Santa Barbara sponsored a two-day symposium on "Operations Research in Space" in Santa Barbara December 18-19, 1968. About 40 people attended. The General Chairman of the Symposium was Raoul J. Freeman, who was also Chairman of the Space Sciences Section of ORSA.

The Symposium produced some new contributions to the literature, some comprehensive evaluations of the state of the art and reviews of past work, and an isolation of

problem areas where additional research is necessary. Among the current mathematical models and development of more comprehensive models.

From *PHALANX*, The Newsletter of the Military Applications Section.

"The MAS prize for the best paper dealing with a military subject in *Operations Research* in 1967 was awarded to Franklin M. Fisher and Morton of Arthur D. Little, Inc. for their paper entitled, 'The Cost of Reenlistment Incentives in the Navy,' which appeared in the May-June 1968 issue of *Operations Research*.

"The prize consists of a \$200 cash award and a certificate. The Prize Committee extend their congratulations to Messrs. Fisher and Morton. Also from *PHALANX*:

"The Military Applications Section plans to continue its practice of an annual prize of \$200 for a paper on military operations research. This year was to consider for the prize only papers on military subjects that had appeared in *Operations Research* during the given calendar year. In 1968, for example, the practice began, papers published in *Operations Research* in 1967 were considered for the prize was awarded to Fisher and Morton. The same general procedure will continue in 1969.

"For the 1969 prize (to be awarded in 1970) a new procedure will be adopted. The prize of \$200 will be awarded to the best paper submitted in response to a solicitation. The winning paper will be printed in *Operations Research* and will be given a special presentation at one of the two following meetings. Papers must be submitted by December 1969, and the Prize Committee will have until 31 March 1970 to select the winner.

"The general objectives of the MAS prize are to encourage high quality conduct of operations research work on military subjects and to enhance the communication of results to a broad professional audience. It is hoped that the new solicitation procedure will encourage the submission of papers that would not otherwise be submitted. Some authors may be induced to 'polish-up' (and/or 'sanitize') some work that is 'almost publishable.' Or the prize may give some thinker just the incentive that he needs for pulling some ideas out of the back of his mind and assembling them to form a 'methodology.'

"Underlying the MAS prize objectives is a fairly general feeling that the number of good operations research papers on military subjects has decreased in recent years. Assessments of quality are rather subjective, but quantity should be determinable. One indication is the number of papers on military subjects published in *Operations Research*. Over the last ten years there have been about 10-12 papers per year on military subjects, whereas the total number of papers in *Operations Research* has increased during that period from some 50 per year to over 80 per year. Thus the fraction of papers accounted for by military subjects has declined from 20-25% to 10-15%. Whether this fractional decrease is matched by a decline in the quality of papers is a moot point. The intent of the MAS prize, however, may be viewed as that of eliminating doubts about quality by making it more obvious that there is still good work, which is reflected in good papers on military subjects."

Note: The Editor of the Bulletin plans to continue presenting excerpts from technical section newsletters. However, members desiring to know all that goes on in the technical sections should join them and receive complete newsletters on a timely basis.

CALL FOR PAPERS: EDUCATIONAL SCIENCES

The Educational Sciences Section will be sponsoring two sessions in Research in Education at the Detroit Meeting. One session will be concerned with theoretical developments and the other with implemented studies. The Section is especially seeking

papers showing application of O.R. methodologies at the primary and secondary school levels. All those wishing to submit a paper should send abstracts to Professor Arnold Reisman, Department of Operations Research, Case Western Reserve University, Cleveland, Ohio 44106.

PERSONAL ITEMS

JAMES G. ABERT has been appointed Deputy Assistant Secretary for Program Evaluation, Department of Health, Education and Welfare.

ROY C. AMARA has joined Dyna/Comp. Inc., a computer supportive service company, as Vice-President, Systems. He was formerly a Vice-President of Stanford Research Institute.

DAVID E. BROWN has been promoted to Manager of Operations Research, Business Products Group, Xerox Corporation, Rochester, New York.

MARVIN R. BURT has joined The Urban Institute as a member of the Senior Research Staff.

Three ORSA members have been promoted by Resource Management Corporation:

ROBERT J. BYER, to Executive Vice President, WILLIAM E. REYNOLDS to Manager, Systems Analysis Division, and CHARLES E. SITES to Vice President for Finance and Administration.

RAMASWAMY CHANDRASEKARAN, SUBBA RAO, and HARVEY SALKIN have joined the faculty in the Department of Operations Research at Case Western Reserve University as Assistant Professors.

WALTER HAHN has been appointed Deputy Assistant Secretary of Commerce (Science and Technology Planning). He was formerly Assistant Deputy Administrator for Policy Development in the Environmental Science Services Administration.

JAMES H. HERD is Senior Scientist, Geomet, Inc., Rockville, Maryland.

SAUL HOCH has been named Director of the Office of Evaluation, Office of the Assistant Secretary for Policy Evaluation and Research, Department of Labor.

JOHN D. C. LITTLE, Professor of Management, was appointed Director of the Operations Research Center at the Massachusetts Institute of Technology. He succeeds PHILIP M. MORSE, first President of the Society, who retired at the end of the academic year.

NORMAN LOCKSLEY has joined the Department of Mathematics, University of Maryland, College Park.

ARTHUR P. MALONEY has been promoted to the position of Leader, Combat Air Section in the Operations Evaluation Group of the Center for Naval Analyses.

JOHN P. MAYBERRY and FREDERIC A. MIERCORT have joined the technical staff of Lambda Corporation.

J. S. MINAS has been appointed Academic Vice-President of the University of Waterloo, Canada.

JOHN G. PHILLIPS has been appointed a Senior Research Analyst in the Systems Analysis Division of Resource Management Corporation.

DAVID R. SEIDMAN has been appointed Research Director for a Special Staff to the U.S. Conference of Mayors. This staff has been newly created to provide technical assistance to city health officials.

KARL SEILER, III has been appointed Business Systems Consultant, Bell Telephone Laboratories, Incorporated, New Brunswick, New Jersey.

EDWARD A. SILVER has been appointed an Associate Professor in the Department of Management Sciences at the University of Waterloo, Waterloo, Ontario. In his new position Dr. Silver will be responsible for coordinating studies in the field of Operations Research.

ANDREW VAZSONYI has been appointed Adjunct Professor of Quantitative Business Analysis in the Graduate School of Business Administration of the University of Southern California.

JAY T. WAKELEY of Santa Barbara, California has been named Director of Research, Operations Research and Economics Division, at the Research Triangle Institute in North Carolina.

ORSA Sections and Their Officers

Revised: 11/14/69

Cost-Effectiveness Section

Chairman: ARMAND WEISS; Vice-Chairman: WILBUR STEGER; Secretary: EDWARD GORETSKY, 8209 Marcy Avenue, Springfield, Va. 22150; Treasurer: DAVID VAN TI JN. Next Election: 9/70.

Health Applications Section

Chairman: WILLIAM HORVATH; Vice-Chairman: JOHN P. YOUNG; Secretary: RICHARD K. C. HSIEH, U.S. Public Health Service Hospital, Wyman Park Drive, Baltimore, Maryland; Treasurer: JOHN FREEMAN. Next election: 5/70.

Military Applications Section

Chairman: JOSEPH BRUNER; Vice-Chairman: EDWARD QUADE; Secretary: MURRAY GREYSON, Stanford Research Institute, Menlo Park, California; Treasurer: RAY TEGTMEYER. Next election: 9/70.

Space Sciences Section

Chairman: CORDELL MOORE; Vice-Chairman: STANLEY ROSS; Secretary: TRAVIS PEACE, General Dynamics Corp., Worth, Texas; Treasurer: DON TURNER. Next election: 11/70.

Transportation Science Section

Chairman: ALFRED BLUMSTEIN; Vice-Chairman: ALAN GOLDMAN; Secretary: LESLIE C. EDIE, The Port of New York Authority, 111 Eighth Avenue, New York, N.Y. 10011; Treasurer: DONALD GAVER. Next election: 9/70.

Educational Sciences Section

Chairman: GUSTAVE RATH; Vice-Chairman: ARNOLD PACKER; Secretary: JACK BORSTING, U.S. Naval Postgraduate School, Monterey, California 93940; Treasurer: BURTON DEAN. Section organized. 5/69.

Geographical Sections

Chicago Section

Chairman: VERNON DORWEILER; Vice-Chairman: SPENCER B. SMITH; Secretary: MRS. MIKI JOHNSON, Operations Research Department, Montgomery Ward & Co., 140 South State Street, Chicago, Ill. 60603; Treasurer: T. S. LEWIS. Next election: 5/70.

Houston Section

Chairman: JOHN W. De FARGES; Vice-Chairman: S. T. POAGE; Secretary: C. R. CUPIT, 10430 Collingswood, LaPorte, Texas 77571; Treasurer: R. E. OBERUC. Next election: 5/70.

Lower Connecticut Valley Operations Research Society

Chairman: GIAP RIETSEMA; Vice-Chairman: JOHN D. CLARK; Secretary: FRANK C. GRELLA, University of Hartford, 200 Bloomfield Ave., West Hartford, Conn.; Treasurer: CHARLES W. BURLIN. Next election: ?/70.

Management and Operations Research Society of Central New York

Chairman: JOHN ALLDERIGE; Vice-Chairman: RALPH SWALM; Secretary: STEPHEN ROYCE, P.O. Box 1333, Syracuse, New York 13201, Treasurer: STEPHEN ROYCE. Next election: 4/70.

Milwaukee Section

Chairman: MIKE NOLEY; 1st Vice Chairman: RUSS FENSKE; 2nd Vice Chairman: LUDWIG IGLHAUT; Secretary/Treasurer: JAMES F. SUTLIFF, Kickhaefer Mercury, Division of Brunswick Corp., Fond du Lac, Wisconsin. Organized. 1969.

North Texas Section

Chairman: H. De WALD; Vice-Chairman: JERRY JAGGERS; Secretary: CALVIN ADKINS, Rt. 1, Box 1309, Smithfield, Texas 76080; Treasurer: HENRY SLAGLE. Next election: 5/70.

Northwest Section

Chairman: NORMAN H. BENNETT; Vice-Chairman: ROBERT C. MEIER; Secretary: RICHARD F. ETTER, 1034 108th Avenue SE, Bellevue, Washington 98004; Treasurer: CARL JANSEN. Next election: 2/70.

Philadelphia Section

President: ROBERT M. STARK; President-elect: JAMES C. GRACE; Secretary: PETER T. FITZ ROY, Marketing Department, University of Pennsylvania, Philadelphia, Pa. 19104; Treasurer: LARRY BUCHSBAUM. Next election: ?/70.

Rocky Mountain Section

Chairman: JACK SHAFFER; Vice-Chairman: GLENN FOSTER; Secretary: JOHN C. RYAN, IBM Corporation, 777 Grant, Denver, Colorado 80217; Treasurer: MARGARET GEICK. Next election: 5/70.

San Diego Section

Chairman: JOSEPH V. RAVENNIS, II; Vice-Chairman: ERVIN AMSTADT; Secretary: MYLES J. SHEEHY, Naval Electronics Laboratory Center, San Diego, Cal. 92152; Treasurer: LAURENCE HARVEY. Next election: 12/69.

Upper Midwest Chapter

Chairman: PAUL JOHNSTON; Vice-Chairman: none; Secretary: THOMAS R. HOFFMAN, 1247 BA Tower, University of Minnesota, Minneapolis, Minnesota 55455; Treasurer: WILLIAM ETTER. Next election: 10/69.

Western Section

Chairman: RICHARD TRUEMAN; Vice-Chairman: PETER ZEHNA; Secretary-Treasurer: LAWRENCE J. LOW, Naval Warfare Research Center, Stanford Research Institute, Menlo Park Cal. 94025. Next election: 1/70.

Student Sections

Case-Western Reserve University

Chairman: DONALD FRIEDEL; Vice-Chairman: ALLAN SERVICE, Secretary: WILLIAM J. BROWN, 19201 Euclid Ave., Apt. 249, Euclid, Ohio 44117; Treasurer: JAMES HARTMAN. Next election: 12/69.

Texas A&M University

Chairman: CLIFFORD TRIMBLE; Vice-Chairman: THOMAS BOONE; Secretary: EDWIN B. WILSON, 1607 Armistead Street, College Station, Texas 77840; Treasurer: DAVID WATTS. Next election: 2/70.

U.S. Naval Postgraduate School

Chairman: W.W. BREEN; Vice-Chairman: THOMAS MULKERIN; Secretary: LEON OBENHAUS, Code 30, NPS, Monterey, California 93340, Treasurer: M. RIZWAN NOMANI. Next Election: 11/69.

University of California, Berkeley

Chairman: HENRY BAKER; Vice-Chairman: KAMALASH BANERJEE; Secretary: PATRICK TOOLE, 3115 Etcheverry Hall, University of California, Berkeley, California 94720; Treasurer: ROBERT STANFORD. Next election: 1/70.

University of Illinois, Chicago Campus

President: JAMES KARLOVSKY; Vice-President: DANIEL MORAVEC; Secretary: LOUIS SHORR, 2636 N. Fairfield, Chicago, Illinois 60647; Treasurer: RICHARD ADAMCZEWSKI. Next election: ?.

